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LOWER COOK INLET CULTURAL RESOURCE STUDY

FINAL REPORT

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INTRODUCTION

This volume comprises the final report of a cultural resource analysis of Alaska's outer continental shelf in the Lower Cook Inlet and Prince William Sound regions of Alaska. This particular cultural resource study represents the fourth such research project undertaken by the University of Alaska Museum for the Bureau of Land Management's Alaska Outer Continental Shelf Office. The area analyzed extends roughly from Cape Suckling in the east to Kamishak Bay in the west. It includes the entire outer continental shelf under federal jurisdiction in and adjacent to Prince William Sound and the federally controlled outer continental shelf in Cook Inlet as far north as Kustatan and Nikishka. All aspects of the research were executed with the ultimate objective of determining, the probability of archeological site occurrence on the outer continental shelf.

During the Pleistocene, a global lowering of sea level occurred as a result of the entrapment of vast quantities of water in the form of glacial ice, exposing vast areas of the outer contintal shelf as dry land. Such habitat most certainly supported human settlements. In Alaska, the outer continental shelf is of particular archeological importance because, when exposed during the Pleistocene times, it created a continuous land connection between North America and Asia. Most anthropological scholars concur that man entered the Americas during late Pleistocene times by crossing the then exposed outer continental shelf, commonly referred to as the Bering Land Bridge. The portion of the outer continental shelf which is the subject of this report, formed a southern extension of the Bering Land Bridge and has been postulated as a probable migration route for the human populations colonizing the New World during Pleistocene times.

An interdisciplinary research team consisting of Dr. G. D. Sharma (marine geologist) , Dr. Samual W. Stoker (biological oceanographer) , and Dr. E. James Dixon, Jr. (archeologist) executed the research. Dr. Sharma's analysis focused on examination of bottom topography, sediment distributions, and geological processes from numerous published and unpublished sources. In addition to a written narrative discussing his analysis and observations, Dr. Sharma prepared bathymetric maps of the study area. These maps have applicability to many scholars and researchers analyzing both biological and physical processes in the study area. For the purposes of this report, they served as base maps from which paleogeographic maps were prepared which represented major sea level stillstands which Dr. Sharma has postulated for the study area based on a previous analysis (Sharma 1977) of the Western Gulf of Alaska. Dr. Sharma's narrative and-maps comprise the first section of this report.

Dr. Stoker's analysis is essentially uniformitarian, in that following an analysis of present ecological conditions, he extrapolates them into the past based on an analysis of paleoenvironmental studies pertinent to the study area. Dr. Stoker discusses his analysis of former ecological conditions for each stillstand postulated by Dr. Sharma and provides maps upon which he has outlined areas of probable species habitat suitable for human exploitation. The maps accompany his written narrative in section II.

Section III of this report discusses the reinvestigation of an archeological site postulated to be of Pleistocene age by Dr. Frank Hibben in the early 1940's. This section, authored by Dr. Robert Thorson, consulting geologist, Mr. David C. Plaskett, research associate with the University Museum, and Dr. E. James Dixon, principal investigator, conclusively demonstrates through geological analysis and radiometric dating that the site is not of Pleistocene age.

Dr. Dixon reviewed archeological research conducted in terrestrial regions adjacent to the study area and delineated a cultural chronology for the region. Significant in this discussion are data indicating that man may have occupied the area for the past 10,000 years, thus suggesting human occupation of terrestrial habitat adjacent to the study area at a time of much lower sea level. Dr. Dixon's narrative . constitutes section IV of this volume.

Based on Dr. Sharma's and Dr. Stoker's analysees, Dr. Dixon ranked the study area for regions of high, medium, and low probability of archeological site occurrence and preservation based on paleoecological criteria and geological processes. All potential OCS lease sale areas were ranked as to archaeological potential. Surveys to identify possible cultural resources are recommended for high potential areas only. Areas of high, medium, and low potential of archeological site occurrence were plotted on BLM/OCS protraction diagrams and are contained in this volume.

I. GEOLOGY , SEA LEVEL HISTORY , AND BATHYMETRIC FEATURES OF LOWER COOK INLET AND A PORTION OF THE NORTHERN GULF OF ALASKA OUTER CONTINENTAL SHELF

G. D. Sharma

COOK INLET

Cook Inlet is located on the northwest edge of the Gulf of Alaska in southcentral Alaska. The Inlet, including Knik and Turnagain Arms, lies between 59°00'11 to 61°30'N latitude and 149°W to 154°W longitude and covers more than 26,000 km^2. This large tidal estuary is a northeast-southwest oriented indentation into the southcentral Alaskan coastline. It differs from other indentations of the Pacific Coast of Alaska in that its head is well behind the coastal ranges and it has a broad tributary valley drained by large rivers. The estuary flows into the Gulf of Alaska between the southwestern tip of the Kenai Peninsula and east of the base of the Alaskan Peninsula. At its entrance, it is 80 km wide and averages 100 m in depth, and extends northeast 280 km and at the head bifurcates into Turnagain and Knik Arms . Cook Inlet is divided into upper and lower inlets by a natural constriction near the east and west forelands.

The Inlet is bordered by extensive tidal marshes, lowlands with numerous lakes, and glacier-covered mountains. Extensive tidal marshes and mud flats are common along much of the western and northern margins of upper Cook Inlet. Lowland areas to the east extend for more than 110 km to the Kenai Mountains. Along the southern margins, especially to the west, lowlands are very narrow and mountains rise directly from the water.

The estuary is fed by the drainage from the surrounding steep mountains: the Aleutian Range and Alaskan Range to the northwest, the Talkeetna Mountains to the northeast, and the Chugach-Kenai Mountains to the southwest. These mountains are heavily glaciated and are rugged. The glacial melt feeds various rivers and streams and is laden with sediments. Major rivers (the Knik, Matanuska, Susitna, Little Susitna, and Beluga rivers) discharge their load near the head in upper Cook Inlet, while the Kenai and Drift rivers drain into lower Cook Inlet.

Geology

Lower Cook inlet lies on the southwest flank of the arcuate Matanuska Geosyncline. Structurally, the sedimentary basin--the Matanuska-Wrangell Basin--is bounded by the Talkeetna Geanticline to the northwest and by the Seldovia Geanticline to the southeast (Payne 1955). The basin extends northeast into the upper Cook Inlet and southwest down the Alaskan Peninsula and Shelikof Strait. The elongated basin is about 320 km long and 110 km wide and covers an area of about 40,000 km^2. In its simplest form, the basin is a graben bounded by major fault zones to the north, west, and east which have been active since Eocene time. The basin is filled with a 20,000 to 25,000 m thick sequence, comprising marine and non-marine sediments, as well as volcanic rocks.

Cook Inlet lies in the trans-Pacific seismic zone and is therefore a region of continued tectonic activity. The unique structural, stratigraphic, and tectonic character of the region suggests that Cook Inlet is a remnant of a former arc-trench system. Accordingly, the thick sequence of sediments in Cook Inlet was deposited on an unstable, shallow continental shelf and slope, prone to periodic updrift and subareal erosion. To the southeast, the deep water facies of the Kenai Peninsula were deposited and later accreted to the continental margin through northwestern underthrusting of the north Pacific Plate beneath the continental plate. The convergence of the-two plates appears to be along the Border Range Fault (MacKevett and Plafker 1974) . The fault marks the eastern boundary of the Matanuska-Wrangell Basin while the Bruin Bay Fault delineates the western edge of the Cook Inlet Basin. The plutonic, extrusive volcanics, volcanoclastic sediments, and metamorphosed sedimentary units which lie west of the Bruin Bay Fault are characteristic of the Alaskan-Aleutian Range.

The stratigraphic sequence in Cook Inlet Basin includes over 12,000 m of Paleozoic and early Mesozoic marine sediments and about 10,000 m of Tertiary non-marine sediments. Tertiary sediments contain hydrocarbons, which are commercially produced in Cook Inlet and from the Kenai Peninsula.

Structurally, little change has occurred in Cook Inlet since the close of the Tertiary. Morphologically, however, the region has been repeatedly affected by glacial advances and retreats. At least five major Pleistocene glaciation have been observed in this region (Karlstrom 1964). Glacier ice during the first three episodes (Mount Susitna, Caribou Hill, Eklutna) filled Cook Inlet, and extended as far as Shelikof Strait. At the peak of the Mount Susitna glaciation, the ice elevation in the CQok Inlet region was 1,300 m. The contiguous sheet of ice during this time perhaps extended from the Copper River Basin to the northeast and into Bristol Bay to the southwest. The Caribou Hill glaciation was less extensive, with ice elevation between 750 and 1,000 m. At the close of this glacial episode, approximately 155,000 to 190,000 years B.P., the ice began to retreat. The Eklutna glaciation was less severe than preceding ones, and ended about 90,000 to 111,000 years B.P.

During succeeding Knik and Naptowne glacial episodes, ice covered only portions of Cook Inlet, with the Knik glaciation ice extending further than Naptowne. Karlstrom (1964) reported that during these two glaciation, upper Cook Inlet and parts of lower Cook Inlet were covered by a large glacial lake which was formed as a result of coalescence of ice lobes from Kachemak Bay in the southwest and from the Aleutian Range in the west. The preglacial lake silt of Knik age is exposed to 300 m elevation. The final draining and subsequent encroachment of the sea in Cook Inlet began about 7,000 years B.P. at the close of the Naptowne glaciation. There have been two major ice advances since the last major glaciation; the Tustumena ice advance peaked between 5,500 to 3,200 years B.P. , and the youngest , Tunnel, climaxed between 1,500 and 500 years B.P.

Bathymetry

The bathymetry of lower Cook Inlet is quite complex (Figures I-1 and I-2). The major exposed features in the inlet are Kalgin Island (near the Narrows) , Augustine Island in the southwest, and Barren and Chugach islands near the entrance. A few smaller islands are scattered in various bays and near the entrance.

Three large bays, Kachemak Bay to the east and Tuxedni, Chinitna, and Kamishak bays in the west, indent the coastline of the inlet. The bathymetry of these bays varies from gradual sloping bottoms to highly complex intervening basins. The floor of the Kachemak, for example, consists of numerous basins separated by ridges and sills of various depths.

The inlet has two sea valley systems. The major sea valley system connects the upper and lower Cook Inlet through the Narrows. In lower Cook Inlet the sea valley bifurcates near the north of Kalgin Island into two arms. One arm of the sea valley extends southward along the coast while the other arm extends along the west of Kalgin Island. South of the island, these two arms unite to form a single valley which extends southwards and slopes into the trough west of the Stevenson Entrance. Throughout the upper reaches of its longitudinal axis the sea valley has numerous elongated basins.

The northern components of the smaller sea valley system which apparently carried the drainage from the Kenai Peninsula is the valley which runs along the longitudinal section of the Kachemak Bay and a conspicuous valley west of the bay. Southward", these two valleys merge together and extend toward the entrance forming a semicircular course which runs parallel to the eastern shore of the inlet. Near the entrance the sea valley gradually slopes into a large rectangular trough of the Kennedy Entrance. This trough was apparently a lake during the lower sea-level stands.

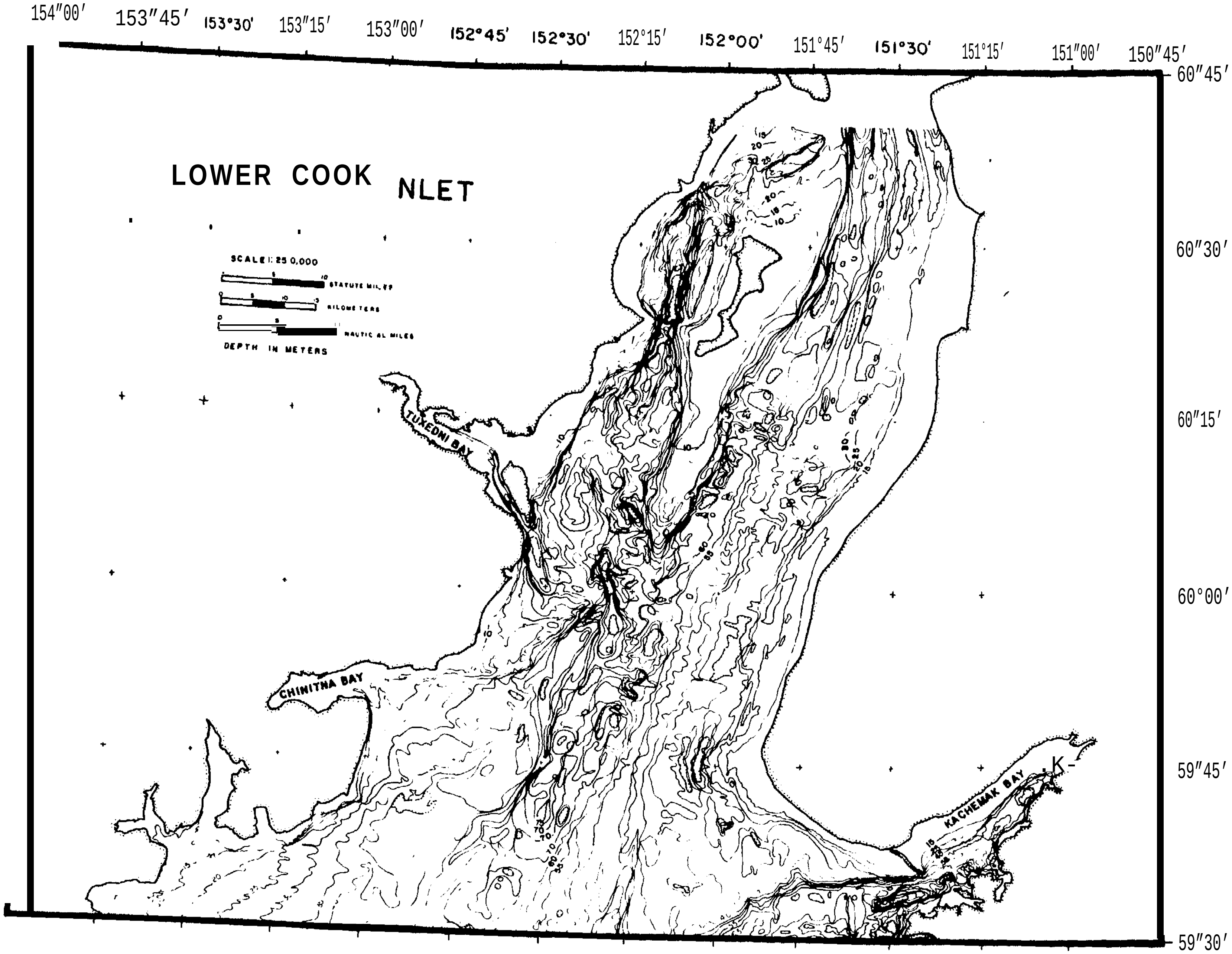
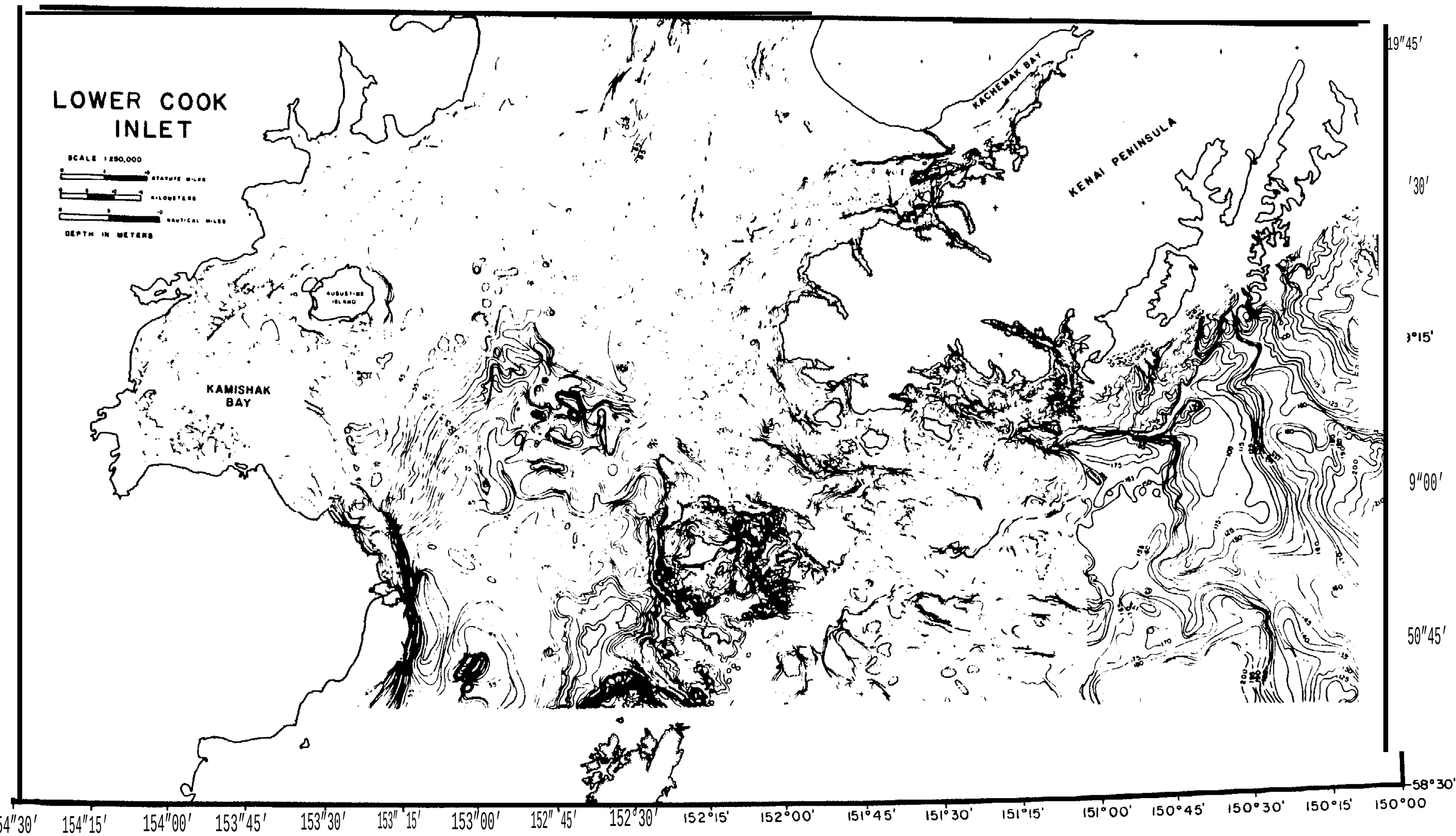


Figure I-1. Bathymetry of Lower Cook Inlet: Kalgin Island to Kachemak Bay



Fiqure 1-2. **Bathymetry** of Lower Cook Inlet: Kamishak Bay through Kennedy Entrance to Two Arm Bay

Lower Cook Inlet, based on its bathymetric features, can be divided into three regions. The inlet floor shallower than -80 m consists of an unusually large number of flat tops and shallow depressions. Most of these flat-top highs are at -55 m depth. The bottom slope of this region is low. Beyond -80 m isobath the depth increases rapidly. This steeply inclined semicircular ramp forms the second bathymetric region of the inlet. A few narrow, steeply walled sea valleys cut across this ramp. At -150 m depth the gradient of the floor once again becomes less inclined and a broad saucer shaped basin occupies the southern part of lower Cook Inlet. This basin lies west of the entrance and forms the third region of the inlet. The configuration of the deep basin and the landward ramp are indicative of a possible bay during lower sea level stands.

To the south, lower Cook Inlet is connected to an elongated depression, Shelikof Strait, which lies between Kodiak Island and the Alaska Peninsula. The bathymetry of the strait has been described in an earlier report (Dixon, Sharma, and Stoker 1977).

To the southeast there are two passages through which the inlet exchanges water with the Pacific Ocean. The northern passage lying between the Barren Islands and Chugach Island is called the Kennedy Entrance. The entrance has a rectangular basin, Kennedy Trough, with a depth over -200 m. The northern and southern rim of this trough are very steep while to the west and to the east the bottom rises gradually into the inlet and into the Gulf of Alaska, respectively. It should be noted that the basin enclosure of the Kennedy Trough is at -125 m depth below sea level. In spite of the complex bathymetry, the sill depth connecting Cook Inlet and the Gulf of Alaska consistently lies along the -125 m isobath. To the east of Kennedy Trough are two east-west oriented ridges. The shallow valley between these two ridges has small basins.

The southern passage to the inlet lies betweenthe Barren Islands and Shuyak Island and is called Stevenson Entrance. The entrance has a narrow channel with a depth exceeding -200 m. To the east of the " channel lies a large bank with a smooth surface. Interestingly, the depth of this bank is -125 m. The floor surrounding the Barren Islands is extremely rugged. Numerous islands rise abruptly from the floor forming basins and ridges between them.

The region east of Cook Inlet entrance consists of broad, smooth banks and intervening troughs. There are also numerous submerged ridges generally extending east to west. Isolated basins are scattered throughout this region.

The shelf of southwestern Kenai Peninsula consists of two broad U-shaped valleys and two prominent ridges. The ridges and the valleys cut across the shelf and slope seawards. The configuration and the orientation of these broad valleys is indicative of their glacial origin.

The bathymetric features in the Lower Cook Inlet suggest that the bottom of the inlet is covered by contemporary sediments. These features are also indicative of the past fluvial, glacial, and marine environments. Many of these features are indicative of lower sea level. In particular, these features support past sea level stillstands reported in earlier studies. With this in mind, we have drawn six paleogeographic maps of this region with sea level stillstands of -28 m, -38 m, -55 m, -66 m, -82 m, and -125 m.

NORTHERN GULF OF ALASKA

The region described here extends from Cape Suckling in the east to the entrance of Cook Inlet to the southwest. This region of the Gulf of Alaska forms the northeastern part of the Pacific Basin. It represents the seaward expansion of a bight, where the northwest-trending North American Cordillera bends to the southwest at least 90° and merges into the eastern end of the Aleutian Arc and the Aleutian Trench. Physiographically and tectonically the region is unique. Landward the shelf is bounded by an arcuate structural trend which is the result of the merging of northwest-southeast trending Chugach-

St. Elias Mountains and the northeast-southwest trending Kenai Mountains. Seaward, these structural blocks are separated from the shelf by a broad fault zone which runs parallel to the shelf. Tectonically the entire region has been active during and since the Tertiary and presently is a site of recurrent earthquakes. This tectonic activity is a result of the release of structural stress caused by the strong relative movement between the Pacific and American plates.

The continental shelf which adjoins the North Pacific Basin is semi-circular and of variable width. This shelf is only 30 km wide in the east and broadens gradually to over 100 km in the southwest. An interesting feature of the shelf is the presence of a small island, Middleton Island, located near the shelf slope. In the northeast, the shelf receives the discharge of the Copper River, one of the largest Alaskan rivers. This river has formed an unusual delta of Holocene sediments. The submerged delta does not prograde seawards but extends parallel to the shore over a distance of 100 km and is separated from the open shelf by a chain of barrier islands.

The shelf also differs tectonically from the adjacent eastern and western shelves. Tectonically it is an area where the northwest trending eastern shelf and the northeast trending western shelf merge. This merging of structural trends resulted in three distinct features which form fundamental regional boundaries on the shelf. Landward, the shelf is bounded by an arcuate broad fault zone which separates the Kenai-Kodiak and St. Elias blocks. Seaward, two large shelves (Prince William Sound and the Gulf of Alaska) are separated by a fault zone. In particular, the sound is a unique large basin with a depth over -400 m. Finally, there is a broad complex anticlinal arch near the shelf break.

Geology

The geologic evolution of the Alaskan Pacific margin is complex, and the early history of the geosynclinal basin is somewhat obscure. The surficial and structural geology of the region has been described by many investigators, notably Miller et al. (1959), Gates and Gryc (1963), Burk (1965), Moore (1969), and Plafker (1967, 1971). The character of Paleozoic and early Mesozoic rocks of the shelf is not known . The entire shelf and the regions adjacent to the Gulf during the Paleozoic was a geosyncline filled with sedimentary deposits. The Paleozoic Era closed without major orogeny and the geosynclinal deposition continued into the Mesozoic Era. The absence of Paleozoic strata could suggest that the shelf region is a Mesozoic accretion to the margin to the older continent margin (Triassic) which lay farther inland.

During the mid-Jurassic a major orogeny occurred, and as a result, the then present tectonic configuration began to evolve and has continued since. The most important features of this orogeny were folding, faulting, and emplacement of numerous plutonic masses. Clastic sediments comprising graywacke and sandstones were deposited during the Jurassic and Cretaceus periods. This was followed by two relatively minor orogenies during Late Cretaceus and Early Tertiary (Oligocene) , succeeded by a major orogeny which began during Late Tertiary (Pliocene) and is presently active in the region (Plafker 1969, 1971).

Late Tertiary orogeny had a profound effect on the evolution of the shelf along the Alaskan Pacific margin and included some onshore regions as well as the shelf - a large elongated continental margin during the Tertiary. During the Tertiary orogeny, a major northeast-southwest trending fault developed along the trend presently occupied by Hinchinbrook, Montague, and Kodiak islands. Due to continual offset along this fault, the seaward shelf in the Gulf of Alaska had significantly different geologic history than the landward shelf in Prince William Sound.

The seaward basin has a broad structural arch near the shelf break, which began rising during Miocene or Pliocene times (Von Huene and Shor 1969). The rising of this arch and concurrent sinking of the Tertiary Basin is associated with the sliding of an oceanic plate under the continental mass along the adjacent Aleutian Trench. This sliding caused uplift near the continental margin and tilting of the entire continental shelf to the northwest. The tilting and subsidence of the shelf has resulted in entrapment of sediments on the shelf. Subsurface sediments and structures at Kodiak have been described by Shor (1965) and Von Huene and Shor (1969). They found that the shelf is filled with 3 to 4 km thick Tertiary sediments off Kodiak. Between Middleton Island and Hinchinbrook Entrance, the sediments are at least 1 km thick. Due to the extreme thickness of sediments deposited, the lower boundary and configuration of the basin remains obscure.

The older rocks were metamorphosed and highly deformed by the middle Jurassic orogeny and therefore cannot be easily differentiated. Overlying Tertiary rocks, can, however, be divided into three lithologic units, each representing three major depositional environments which prevailed on the shelf (Plafker 1971). The lower Tertiary unit consists of continental pillow lava, tuff, and tuffaceous sandstone and siltstone. The middle Tertiary unit is a marine sequence with mudstone, siltstone, and occasional sandstone beds. The thick bedded upper Tertiary unit (over 5,000 m) is comprised of characteristic shallow water deposits, consisting of mudstone, muddy sandstone, and glacial detritus. Part of the Tertiary sequence is exposed in Prince William Sound and on Kodiak Island.

The Pleistocene Epoch throughout the region is generally associated with glaciation. Glaciation on the shelf and the adjacent land, however, has not been investigated in detail. Although Miocene glacial detritus interbedded with marine sediment deposited 10 million years ago have been observed, these are not widespread. Since then, there have been a number of glacial episodes in this region. During the Pleistocene Epoch, extensive icefield end piedmont glaciers repeatedly covered the shelf. The glacial ice cover over the shelf during the Wisconsin is not clear. It is, however, apparent that the entire shelf is extensively glaciated and that there is evidence for glacial sediments on the slope. At the peak of late Wisconsin glaciation (16,000-12,000 B.P.), much of the continental shelf and part of the slope were covered with glacial ice (Hopkins 1972). Subsequently, a warming trend caused the recession of ice from the shelf, concurrently raising the sea level from -125 m to the present sea level.

The morainal deposits of Malaspina and neighboring glaciers provide some clues to the recent past glacial history of this region (Plafker and Miller 1958). These investigators observed an impressive glacial advance which reached its peak between 700 and 1,400 B.P. During the peak of this advance, the glacial ice probably extended across some parts of the shelf and onto the slope. A warming trend beginning about 600 B.P. initiated a minor interglacial period. The last ice advance started about 275 B.P. and lasted only about 200 years. With the exception of a few, most glaciers now are either stagnant or receding.

Bathymetry

The bathymetry of the northeastern Gulf of Alaska Shelf is complex and typical of a glaciated shelf (Figures I- 3 and I-4). There are numerous broad U-shaped valleys that cut across the shelf. Most of these sea valleys are seaward extensions of fiords which form the present coastline. These valleys commonly have intervening basins and an occasional sill near the mouth. Large smooth banks are also common.

In the southeast corner (Figure I-3) , the shelf has a series of troughs and banks. An oblong deep basin lies near 58°00'N latitude and 149°35'W longitude. To the northeast an east-west oriented ridge (58°15'N and 119°50'W) separates this basin into two shallow troughs (58°30'N and 149°50'W; 58°23'N and 149°30'W) . The top of the ridge is slightly smooth and lies at a depth of -66 m water depth. The smoothing of the ridge probably occurred during the -66 m sea level stillstand observed in other regions of the Alaskan Shelf. It should also be noted that the two shallow troughs are separated by

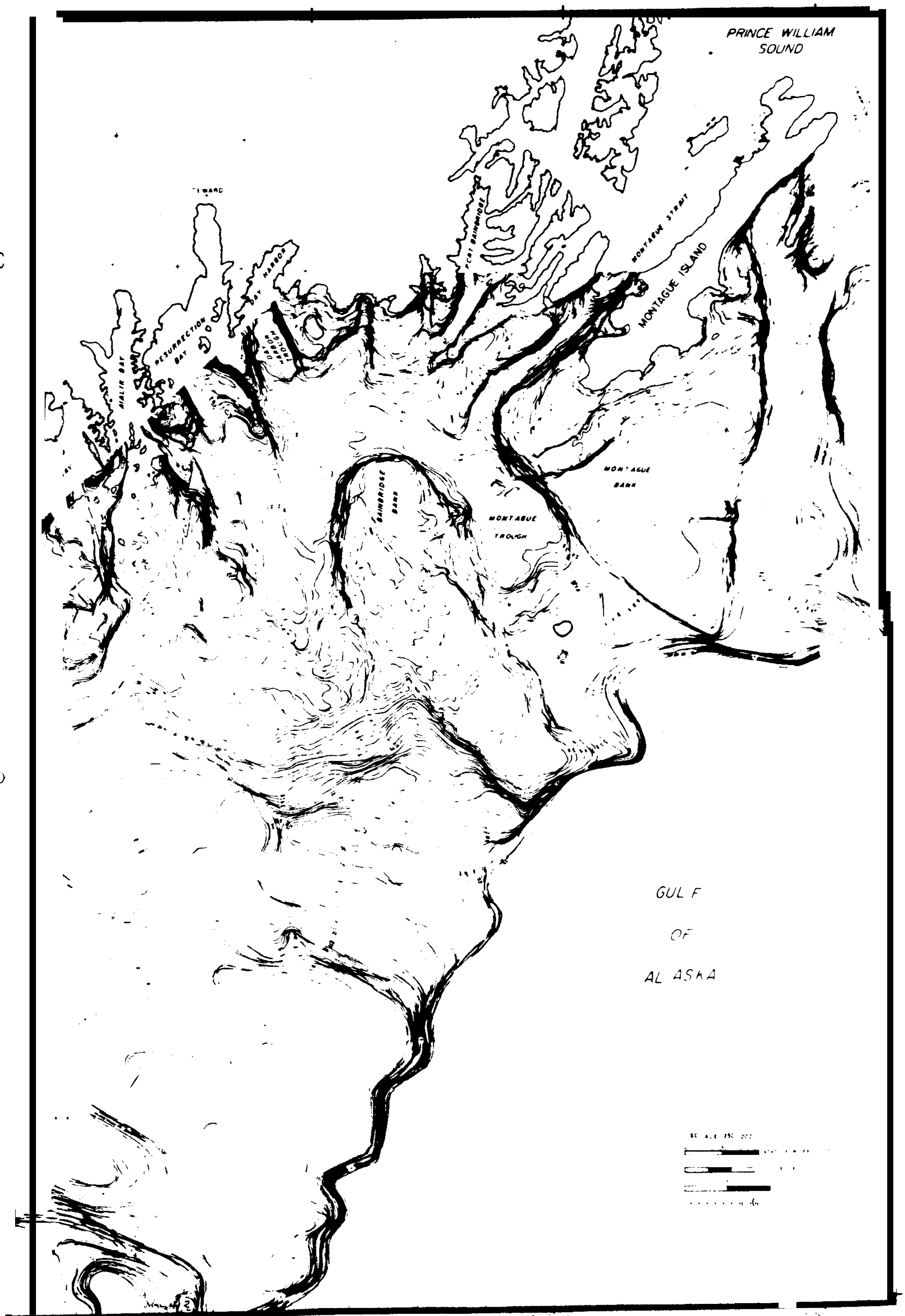
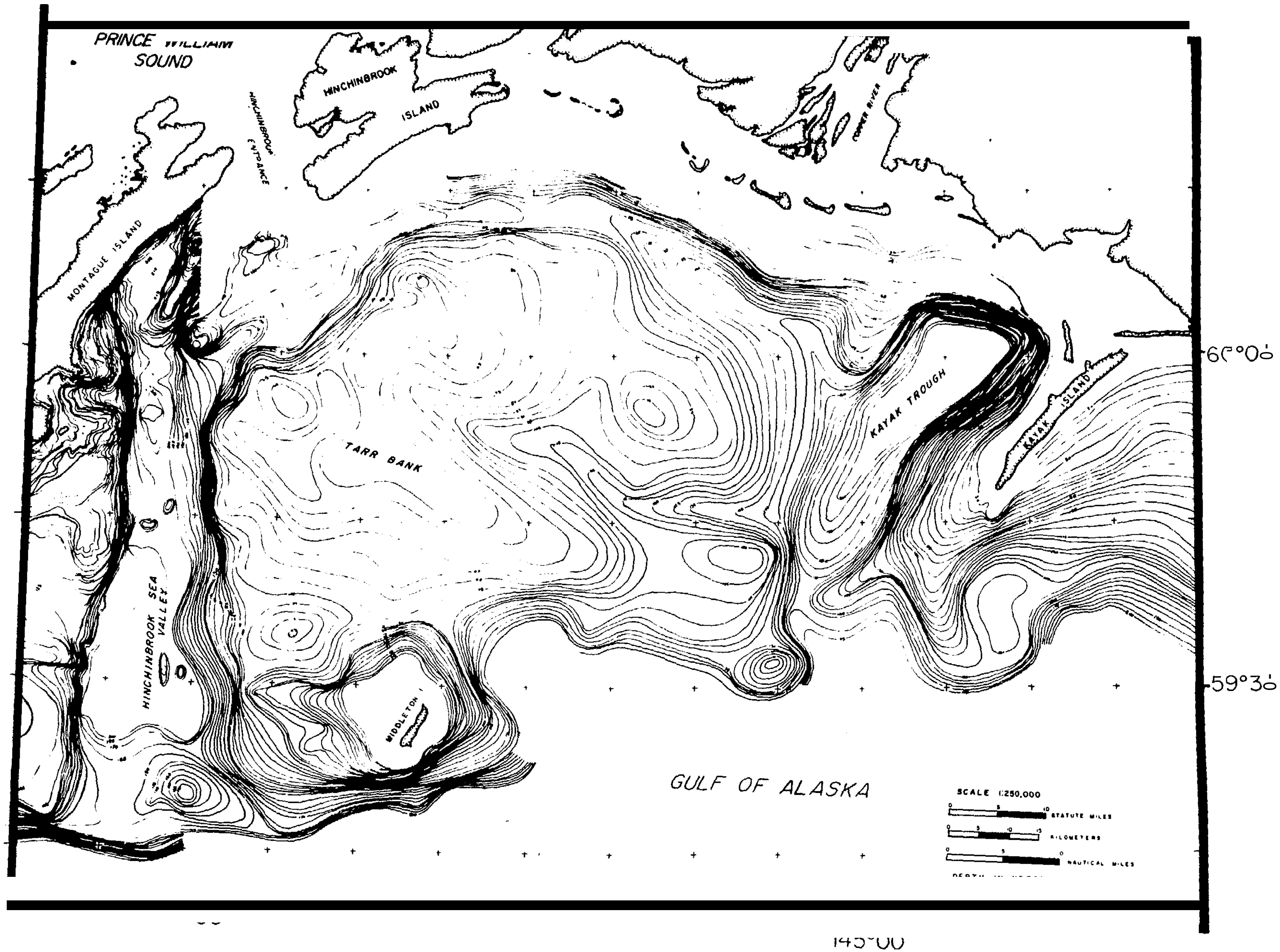


Figure I-3. Bathymetry: Two Arm Bay to Montague Island



PRINCE WILLIAM SOUND
HINCHINBROOK ISLAND
HINCHINBROOK ENTRANCE
COPPER RIVER
MONTAGUE ISLAND
TARR BANK
KAYAK TROUGH
KAYAK ISLAND
HINCHINBROOK SEA VALLEY
MIDDLETON I.
GULF OF ALASKA
SCALE 1:250,000
STATUTE MILES
KILOMETERS
NAUTICAL MILES
60°00'
59°30'
145°00'

a broad bank with a water depth of -125 m. Similarly, the larger trough has a -125 m sill which connects it to the slope. The bank and the sill probably were formed during the -125 m sea level still-stand of late Wisconsin peak glaciation.

Northward, at 59° latitude lies an east-west oriented U-shaped valley. This valley is bisected by a small ridge. The western part of this valley is an almost circular trough with steep walls to the north and south. The northern flank of this trough has a large terrace at -125 m. This -125 m terrace also separates the trough from a small basin (59°17'N and 19°23'W) to the north. It is apparent that the broad terrace and the sill at -125 m are a shoreline feature formed during an earlier sea level stillstand.

The bathymetry south and east of Resurrection Bay is extremely complex. The rugged topography of the sea floor is the result of extensive glaciation. The glaciers from Resurrection Bay and the present Ellsworth and Excelsior glaciers from Day Harbor and the adjacent valley to the east, respectively, in the past descended from the mountains and coalesced on the shelf. This huge glacier was divided into two lobes by a long broad bank. The bank is oriented northwest-southeast across the shelf.

One lobe of the glacier turned south and then southeast along the bank. The northern lobe turned east and was joined by glaciers descending from the north through Montague Strait. This lobe gouged a broad U-shaped valley along the northeastern margin of the bank. The valley is bisected by a prominent ridge. The origin of this ridge may be structural or it may be an end moraine.

The elongated bank which separates these lobes has two terraces at -125 m and -82 m, respectively. It appears that these features are remnants of earlier sea level stillstands.

South of Montague Island is a large triangular shaped bank. The area bounded by -120 m is relatively smooth. The gradient along the side of the bank beyond -125 m is extremely steep. It appears that the smooth surface of the Montague Bank is the result of structural factors, glaciation, and marine abrasion. The top of the bank has a -110 isobath which may be the result of contemporary sediment deposition.

Offshore, the region between Montague and Kayak islands is a shallow region calied Tarr Bank. The bank is circumvented by a moat-like depression. The eastern portion of this moat is called Hinchinbrook Sea Valley while to the west lies a north-south basin, known as the Kayak Trough. The unusual feature in this region is Middleton Island which lies close to the slope of the shelf.

The past glaciers from Prince William Sound via Hinchinbrook Entrance, Copper River valley, and part of Bering Glacier apparently occupied the depression surrounding the Tarr Bank and carried the ice to the shelf edge.

Paleogeographic Maps

Excellent evidence for the past sea level still-stands was observed throughout the southwestern Gulf of Alaska Shelf. The geomorphic features indicative of shoreline and basin enclosures were consistently observed at -28 m, -38 m, -55 m, -66 m, -82 m, and -125 m. Similarly, bottom features from the Bering, Chukchi, and Beaufort shelves revealed paleo-sea level stands at the above horizons (Sharma 1977) .

Numerous bottom features observed in Cook Inlet support past sea level stillstands observed on other Alaskan shelves. The northwestern shelf has many features which indicate paleo-sea level stillstands at -66 m, -82 m, and -125 m. The evidence for shallower paleo-sea level stands is perhaps preserved in nearshore areas for which detailed bathymetric data are not available. In view of the universality of the sea level stillstands throughout the Alaskan Shelf, we have prepared a paleogeographic map for each sea level stillstand.

BATHYMETRIC DATA SOURCES

The bathymetric charts for lower Cook Inlet and the northeastern Gulf of Alaska Shelf were prepared using recent data from various sources. The" most recent data for lower Cook Inlet were obtained from the Patty Ray Geophysical Survey, Alaska; the Continental Shelf Data Service, Denver, Colorado; and USGS unpublished charts provided by the BLM Outer Continental Shelf Office, Anchorage, Alaska. The bathymetric data for the northeastern Gulf Shelf were obtained from Continental Shelf Data Service, Denver, Colorado, and earlier Coast and Geodetic charts.

Considerable difficulty arose during preparation of these maps. First, the detailed bathymetric charts for lower Cook Inlet prepared by USGS did not match with the BLM base map of 1:250,000 scale. This necessitated preparation of lower Cook Inlet bathymetric charts through replotting of data collected by USGS and also by converting Continental Shelf Data Service information available on different projection, scale, and units.

Similarly, preparation of maps for other parts of the shelf required conversion of data from charts of different projection, scale, and units. These difficulties were overcome by reading thousands of points from earlier charts and replotting them on base charts provided by the BLM office. This led to unforseen delays in map preparation.

The bathymetric charts prepared for this report are the most up-to-date now available and show bathymetric detail previously found only on scattered charts of various origins. These maps are very useful in delineating the paleo-sea level stillstands in these regions.

II. ECOLOGICAL CONDITIONS AND FAUNAL DISTRIBUTIONS OF THE LOWER COOK INLET AND OUTER PRINCE WILLIAM SOUND CONTINENTAL SHELF DURING THE LAST WISCONSIN SUBMERGENCE

Sam W. Stoker

INTRODUCTION

Present Geography and Environment

The area covered in this report lies between 144°W and 1540117 longitude and 59°00'N and 60°30'N latitude, and includes the lower half of Cook Inlet and the Kenai Peninsula, outer Prince William Sound, and the Copper River Delta and Controller Bay east to Cape Suckling. This is primarily an area of mountainous, irregular, and often glaciated coastline, and encompasses numerous offshore islands and several major river outlets. Due to the considerable complexity, variability, and ecological diversity encountered, it seems expedient, for purposes of description and analysis, to divide this region into two subunits according to topography and environment. These are (1) all of the coastal region lying west of Cape Suckling and southeast of the Kenai Mountains, (2) Lower Cook Inlet and the Kenai Peninsula northwest of the Kenai Mountains.

The discussion which follows will describe, in general terms, environments and faunal resources which presently exist within these subunits. Correlative information between present environmental factors and faunal resource distributions will then be used to extrapolate shifts in resource distribution as conditions altered through time. Factors of importance include: (1) topography and drainage patterns, (2) vegetation, (3) weather patterns, (4) nearshore marine current patterns and water mass structure, (5) marine productivity distributions, and (6) faunal resource distributions.

1. Cape Suckling to the Kenai Mountains and Kennedy Entrance

This subunit includes considerable complexity and diversity. In the eastern sector from Cape Suckling to Hinchinbrook Island, the coastal morphology is dominated by low deltaic outwash deposits, coastal bogs and marshes, extensive mudflats, and low barrier islands. Several major rivers empty into the Gulf of Alaska within this eastern sector, principal among which are the Copper and Bering. In the vicinity of Katalla, this low coastal configuration is interrupted briefly by the approach of the Ragged Mountains and associated forested elevations to the coast. As will be discussed later, this Katalla enclave may have served as an ice-free refugia during the height of Wisconsin glaciation.

The central part of the subunit, from the eastern tip of Hinchinbrook Island to Montague Strait, is an area dominated by rugged, heavily forested islands, including Hinchinbrook, Montague, Knight, Latouche, Evans, Bainbridge, Chenega, and Green. The coastline of this sector, that of the islands as well as the mainland, is highly dissected and complex, consisting of numerous deep fiords, bays, inlets, and passages.

The western sector of the subunit consists of the southeastern margin of the Kenai Peninsula. This is an extremely rugged, heavily forested, and deeply dissected coast with numerous tidewater glaciers and very deep fiord-type bays including Port Bainbridge, Resurrection Bay, Aialik Bay, Harrison Bay, Nuka Bay, and Port Dick.

Over most of the eastern sector of the subunit, from Hinchinbrook Island to Cape Suckling, the coastal ecosystem is characterized by low wet tundra. The major exception to this rule is the Katalla enclave, where forest and alpine tundra systems dominate. Within the low areas characterized by wet tundra, there are extensive growths-of willow and alder along the stream courses, and sometimes broad expanses of coarse salt grass on the barrier island and along the mainland beaches.

Over the central and western sectors, and within the Katalla enclave of the eastern sector, climax vegetation in the lower elevations is dominated by dense forests of spruce and western hemlock, with local areas of muskeg tundra, salt grass, and willow and alder thickets. In the higher elevations, above 300 m, alpine tundra prevails.

The weather over this entire subunit is classed as maritime (Johnson and Hartman 1969), dominated by the influence of the Alaskan Gyre, a marine current system which sweeps counterclockwise around the Gulf of Alaska. Precipitation over the entire area is relatively heavy, ranging in general from 200 to 250 cm per year and averaging 225 cm per year. The mean annual temperature is 5"C, with a seasonal variation of only 7° to 8°C. Snow sometimes accumulates to considerable depths, particularly in the higher elevations. The area is not subject to extensive sea ice, though seasonal ice forms in shallow bays and estuaries, particularly within Prince William Sound.

Indigenous large mammal species inhabiting this subunit are brown bear, black bear, and mountain goat. Goats frequent virtually all of the higher elevations on the mainland and on the larger islands. Both brown and black bear inhabit the mainland forests, though only brown bear have colonized the larger islands. Black bear seem to be limited primarily to forested areas, avoiding the more exposed alpine and muskeg tundra habitats. Brown bear are more ubiquitous, frequenting all habitat types in this area.

There is, at present, a viable moose population with the locus in the Copper River Delta, and elk and black-tailed deer on several of the larger islands. All of these populations, however, are the result of transplants during this century.

Numerous species of smaller mammals also inhabit this region, including wolf, coyote, wolverine, snowshoe hare, river otter, red squirrel, porcupine, beaver, mink, marten, ermine, lynx, and microtine rodents. With the exception of snowshoe hare, coyote, and wolf, all of these species are much more numerous in the forested areas. Wildfowl are found over the entire region, and are particularly numerous in the Bering River flats and Copper River Delta. Freshwater fish, principally cutthroat and dolly varden trout, inhabit virtually all of the clear streams of the area.

Nearshore marine resources are fairly abundant in this area. Spotted (harbor) seals, Steller sea lions, and sea otters are found throughout the region. Spotted seals are especially numerous in the Copper River Delta-Controller Bay vicinity, while sea lions and sea otters are more common among the islands and in the mainland bays of Prince William Sound and the Kenai Peninsula. Marine fish, including halibut, flounder, sole, sculpins, cod, greenling, smelt, and numerous other species occur throughout the area, though their availability and diversity is generally higher in the Prince William Sound-Kenai Peninsula sectors due to greater habitat variability. The same applies to intertidal invertebrates. Though several species of bivalve mollusks are available throughout the region, only along the rocky shores of Prince William Sound and the Kenai Peninsula are such bivalve resources readily supplemented by other intertidal invertebrates such as urchins, chitons, limpets, gastropod mollusks, rock scallops, tunicates, crab, and shrimp. All of the area is characterized by high tidal ranges, 3.7 to 4.6 m in most places, making such intertidal resources readily accessible where they do occur. Heavy runs of anadramous fish, including pink salmon, red salmon, silver salmon, king salmon, dolly varden, and steelhead trout, utilize, according to the preference of their species, virtually all of the streams of the region.

While the marine resources of this region are considerable, it should be pointed out that they do not attain the levels of abundance and diversity witnessed in comparable adjacent areas such as the Kodiak Island vicinity to the northwest or the Alexander Archipelago to the southeast. Probably this is due to the current transport and salinity structure of the region, particularly Prince William Sound. Prince William Sound is virtually an inland sea, with primary exchange limited to Hinchinbrook Entrance and Montague Strait. Virtually all of the inflow is through Hinchinbrook Entrance, and all of the outflow through Montague Strait. The inflow through Hinchinbrook Entrance includes low salinity, high turbidity Copper River water, entrained and swept up the coast by the Alaskan Gyre. Within Prince William Sound this salinity/turbidity effect is further accentuated by glacial runoff, which entrains and outflows through Montague Strait and sweeps southwest along the Kenai Peninsula coast (Dr. Thomas Royer, University of Alaska, Unpublished data). This lowered surface salinity results in generally intense vertical stratification and restricted nutrient exchange. In combination with increased surface turbidity and restricted light penetration, the effect of this stratification and restricted exchange is lowered productivity at the primary and subsequent levels. The salinity effect itself may be extreme enough to directly suppress or exclude the development of some elements of the intertidal and shallow subtidal community. This seems especially probable for intertidal invertebrate populations, which appear depressed both in terms of standing stock and diversity when compared with adjacent areas of similar habitat.

Anadromous fish resources do not appear to be adversely effected by these conditions. These are seasonal, spawning populations, and do not rely on the productivity of that particular area for their major growth and development. The same can be said of the pinniped marine mammals, seals, and sea lions, which follow the runs of anadromous fish.

In terms of faunal resources available to subsistence hunters, practically the entire area presents acceptable potential. The only areas within which physical conditions or low resource availability and diversity might discourage human settlement are the Copper River Delta and the Bering River-Controller Bay flats. Considering the general paucity of large terrestrial mammals, any subsistence economy in this region must be based primarily on marine resources.

2. Lower Cook Inlet-Northwest Kenai Peninsula

This subunit also consists of essentially three separate sectors--the Kenai Peninsula south of Kachemak Bay, the Kenai Peninsula north of Kachemak Bay, and the Alaska Peninsula coast.

The first of these, the Kenai Peninsula south of Kachemak Bay, is a rugged, mountainous coast of deep fiords. Principal among these are Port Graham, Seldovia Bay, Tutka Bay, Sadie Cove, and Halibut Cove. The terrestrial ecosystem of this sector is dominated by spruce-western hemlock forest in the lower elevations and alpine tundra in the uplands. Patches of muskeg tundra and willow and alder thickets also prevail locally in the lower areas.

The Kenai Peninsula north of Kachemak Bay presents, by contrast, a relatively straight, featureless coast, and generally flat terrain. Spruce-western hemlock forest occupies the better drained portions of this coast, particularly in the southern region, with muskeg tundra and stunted black spruce or birch replacing it in the lowlands to the north.

The Alaska Peninsula shore of Cook Inlet, like the Kenai Peninsula south of Kachemak Bay, is a rugged, mountainous coast for the most part, deeply indented by numerous bays and fiords. Principal among these are Kamishak Bay, Bruin Bay, Ursus Cove, Iliamna Bay, Iniskin Bay, Chinitna Bay, and Tuxedni Bay. This region is also largely dominated by spruce-hemlock forest in the lower elevations, though large areas of wet tundra, willow-alder thickets, and salt grass flats also prevail.

The climate of this Lower Cook Inlet-Northwest Kenai Peninsula subunit is significantly colder and drier than the Cape Suckling-Kennedy Entrance region considered earlier. The mean annual precipitation here is only 56 cm per year, ranging locally from 50 to 150 cm. The mean annual temperature is 2° to 5°C. Seasonal sea ice forms in upper Cook Inlet and along the northwestern shore, primarily as a result of the decreased salinity encountered there.

The smaller terrestrial mammal fauna of this subunit is essentially the same as for the previously considered region. The large mammal fauna is, however, somewhat different. Both brown and black bear frequent the entire area. Mountain goat frequent the Kenai Peninsula south of Kachemak Bay, though not the Alaska Peninsula nor the Kenai north of Kachemak Bay. In addition, moose are abundant in the Kenai lowlands north of Kachemak Bay and along the Alaska Peninsula. Caribou are also found on the Alaska Peninsula south of the Iniskin Peninsula, and in the Kenai lowlands.

Marine resources also offer considerable abundance and diversity, particularly along the Kenai Peninsula south of Kachemak Bay. Marine and anadromous fish, marine mammals, and intertidal invertebrates are all abundant along this coast. These resources are also available over the rest of the region, though in lesser abundance and diversity. Sea lion and sea otter, for instance, do not generally frequent Cook Inlet north of Kachemak Bay. This distribution is partly due to coastal configuration and habitat diversity, partly to the prevailing circulation system. Cook Inlet conforms to the classic estuarine system, with oceanic water of high nutrient content and relatively high salinity entering at depth and along the right-hand (Kenai) shore. Terrestrial runoff of low salinity and high turbidity stratifies near the surface and outflows along the Alaska Peninsula side. This sytem results in increased productivity levels near the mouth of the inlet, particularly along the eastern shore. The same is true, individually, for each of the coves and bays encountered. Tides in this region are very high, running 7 to 10 m.

As for the previous subunit considered, this area offers sufficient resources to support subsistence economies over virtually its entire extent. The focus of such economies, however-, would probably vary depending on locality. For the Kenai south of Kachemak Bay, primary emphasis would almost certainly be on marine resources. For the Kenai lowlands north of Kachemak Bay, terrestrial resources, principally moose, might play a dominant role. For the Alaska Peninsula, marine and terrestrial resources would probably occupy mutually supporting positions.

LATE WISCONSIN ENVIRONMENTS

Extent of Glaciation

At the height of Wisconsin glaciation, approximately 25,000 to 20,000 years ago (Franzel 1973, Karlstrom 1966, Dansgaard et al. 1969, Swanston 1969), sufficient water was invested in continental glaciation to lower worldwide sea level by about -125 m, exposing most of the fringing continental shelf. For the region under consideration, the physical conditions over that exposed shelf during the Late Wisconsin are a matter of conjecture and dispute. This particularly relates to the extent of glaciation during the first half of the period in question, from 20,000 to about 10,000 years ago.

One view (Karlstrom 1964, Cooper 1942, Deevey 1949, Péwé 1975) is that most of the region, including the emergent continental shelf, was heavily glaciated and virtually devoid of faunal resources until roughly 10,000 years ago. The contradictory view (Miller 1953, Reid 1970, Detterman and Hartsock 1966) is that Late Wisconsin glaciation may have been only slightly more extensive than present, leaving most of the emergent shelf glacier-free and perhaps habitable by subsistence hunters. Unfortunately, questions regarding extent of glaciation cannot be resolved at this time with any degree of certainty.

Climatic Sequence

There also seems to be some disagreement as to-the climatic sequence which prevailed over this region during the Late Wisconsin, though such disagreement generally pertains to temporal detail rather than to major climatic shifts.

For the early part of the period, prior to about 12,000 B. P., little concrete information is available. Karlstrom (1955, 1957, 1966) describes a general withdrawal for the Cook Inlet region at 19,000 B.P., which presumably reflects climate amelioration following the Wisconsin maximum. Glacial evidence from Prince of Wales Island, in the Alexander Archipelago to the southeast of the study area, however, indicates glacial advance for the period 20,000 to 15,000 B.P. (Swanston 1969). This Prince of Wales Island advance might, of course, merely reflect local conditions. Karlstrom proposes that the next major glacial retreat in the Cook Inlet region took place about 15,500 to 1S,000 B.P. (Table II-l). If this retreat is construed as reflective of climate warming, a possible conflict again arises. In this case the conflict stems from palynological evidence from the Pacific Northwest (Heusser 1966) which indicates a cold, dry climate for the period 15,000 to 12,500 B.P. Again, such evidence may be indicative only of local conditions.

The next major glacial retreat evidenced in the Cook Inlet area is dated at 12,500 B.P. This retreat corresponds very well with Huesser's (1966) pollen evidence from the Pacific Northwest, which indicates a warm, wet climate for the period 12,500 to 11,000 B.P. Glacial evidence from southeastern Alaska (McKenzie and Goldthwait 1971) indicates rapid glacial retreat dated 10,940 B.P. Widespread micropaleontological and oxygen isotope evidence from other areas in the northern hemisphere also suggest a sudden general warming trend dated to about 13,000 to 11,000 B.P. (Langway et al. 1973; Urry 1948; Erickson and Wollin 1956; Curray 1965; Erickson et al. 1964a,b).

While accepted by most sources to have been a period of major climatic reversal, this warming trend at 13,000 to 11,000 B-P. may have been of relatively short duration. Heusser (1966) feels that the Pacific Northwest in general reverted back to a cold, dry climate for the interval 11,000 to 10,500 B.P., as do Miller and Anderson (1974) for the Juneau, Alaska, vicinity for the interval 11,000 to 10,000 B.P. Oxygen isotope data from Greenland (Dansgaard et al. 1969;

Table II-1. Periods of glacial retreat in the Cook Inlet region according to Karlstrom (1955, 1957, 1966). The retreat dates listed below for each year of reference refer to time before present.

1955	1957	1966
--	--	26,000
--	--	22,500
19,000	19,000	19,000
15,500	15,000	15,500
12,500	12,500	12,500
9,000	9,000	9,000
5,500	6,000	5,500
--	4,500	--
--	3,500	--
--	2,500	--
1,500	1,500	1,500

Langway et al. 1973) also indicate a major reversal back to a cold climate at about this time.

By about 10,000 B. P., the climate appears to have altered course again, from cold and dry to cool and wet. This change probably entailed increased precipitation more than increased temperature. The duration of this cool, wet interval is somewhat open to speculation. Heusser (1960, 1966) feels that over the Pacific Northwest it lasted from about 10,500 to 8,500 B.P., and from about 10,000 to 8,000 B.P. in southcentral Alaska. Miller and Anderson (1974) suggest that in the Juneau vicinity it lasted only from 10,000 to 9,000 B.P. A glacial advance on Prince of Wales Island (Swanston 1969) , dated at 10,000 to 8,000 B.P. may reflect this increased precipitation. Goldthwait (1966) documents a glacial advance for the Lituya Bay region for a slightly later time period, 8,600 to 7,300 B.P.

Another major reversal, back to a warm, dry climate, is generally postulated as occurring sometime after 9,000 B.P. For the Pacific Northwest the duration of this warm interval is dated 8,500 to 4,500 B.P. (Heusser 1966). For southeastern Alaska it is dated variously at 7,700 ± 300 B.P. to 3,500 ± 250 B.P. (Heusser 1966) , 7,200 to 2,900 B.P. (Goldthwait 1966), and 9,000 to 2,500 B.P. (Miller and Anderson 1974). Miller and Anderson propose that this warm interval suffered at least one reversal to a cooler, wetter climate between 8,000 and 5,500 B.P. For southcentral Alaska, this warm interval is dated at 8,000 to 3,500 B.P. (Heusser 1960). This information accords well with Karlstrom's data from Cook Inlet indicating glacial withdrawal for 9,000 B.P., 6,000 to 5,500 B.P., 4,500 B.P., 3,500 B.P., and 2,500 B.P. At some time during this warm interval, the Late Wisconsin hypothermal, defined variously as the “climate optimum” or “temperature maximum,” probably occurred. In southeastern Alaska this hypothermal is dated by various authors at 5,500 to 3,250 B.P. (Miller and Anderson 1974), 7,050 to 4,150 B.P. (McKenzie and Goldthwait 1971), and 3,500 ± 250 B-P. (Heusser 1953). These dates generally agree with corresponding ones from Greenland (Langway et al. 1973, Dansgaard et al. 1969) , the

Seward Peninsula/Chukchi Sea coast (McCulloch end Hopkins 1966, McCulloch 1967), the Brooks Range (Porter 1964, McCulloch 1967), the MacKenzie Delta and Alaskan north slope (Detterman 1970, McKay and Terasmae 1963, Richie and Hare 1971, Livingston 1957), and Siberia (Kind 1967).

Following this warm interval and "climatic optimum," conditions apparently reverted once more to a colder regime. Heusser (1966) feels that for the Pacific Northwest the climate was cooler and drier between 4,500 and 3,000 B.P., and cool and wet from 3,000 B.P. to the present. Miller and Anderson (1974) indicate that for southeastern Alaska the climate may have been cooler and wetter than at present for the period 2,500 to 750 B.P. This information is summarized in Table II-2.

Vegetational Succession

Due to uncertainty about the extent of Late Wisconsin glaciation, any statements concerning the vegetational regime which might have existed in this region prior to about 11,000 B.P. are bound to be highly speculative. If the region was as heavily glaciated as some investigators seem to feel, then virtually no vegetation could have existed prior to about 11,000 B.P. except in isolated refugia (Klein 1965). The fact that none of the pollen cores so far examined from the region date earlier than 11,000 B.P. would seem to support this theory (Heusser 1958, 1965; Miller and Anderson 1974). It must be remembered, though, that all of these cores are from terrestrial areas which might be expected to have been glaciated; none of them are from the submerged continental shelf. If this continental shelf was not glaciated, it seems safe to assume that it supported, prior to 11,000 B.P. at least, a cold tundra or tundra-steppe environment such as is generally proposed for adjacent terrestrial areas for that time (Deevey 1949; Heusser 1958, 1965). Once major post-glacial amelioration began, tending to a warmer, wetter climate, a vegetational succession

Table II-2. Proposed climatic and vegetational sequences for the Cook Inlet-Prince William Sound region, Alaska. Compiled and synthesized from various authors.

Period (B.P.)	Climate	Vegetation
20,000-13,000	Cold/Dry	Tundra or Tundra-Steppe
13,000-11,000	Warm/Wet	Willow, Alder, Spruce, Tundra
11,000-10,000	Cold/Dry	Willow, Alder, Tundra
10,000- 9,000	Cool/Wet	Willow, Alder, Tundra
9,000- 3,000	Warm/Wet	Willow, Alder, Spruce, Hemlock, Birch
3,000- 0	Cool/Wet	Present

from tundra through willow/alder to the present pattern of spruce/hemlock/birch is hypothesized (Heusser 1958, 1965; Klein 1965).

Faunal Succession .

AS for the vegetation, the faunal complexes which might have occupied this region over the time period in question are highly speculative. This is particularly true of the early half of the period, before about 11,000 B.P. At least one author (Klein 1965) feels that the region supported essentially no terrestrial mammalian fauna, except in limited areas of small-mammal refugia, prior to 10,000 B.P. Klein feels that even after climatic amelioration and glacial retreat, the spread into this area by most large mammals would have been severely impeded by existing natural barriers such as tidewater glaciers, icefields, precipitous mountain ranges, and large, swift rivers.

This view seems supported by historical distributions. With the exception of mountain goat, brown bear, and black bear (and moose, caribou, and perhaps bison on the Kenai Peninsula-Cook Inlet locality) , there is no evidence that the region was inhabited by any large mammal populations during historic or prehistoric times. The evidence for bison is restricted to a single find in the Anchorage area, radiocarbon dated at 200 to 500 B.P. (R. D. Guthrie, Univ. of Alaska, vive vote). Populations of moose and bison in the Copper River valley, Sitka deer in Prince William Sound, and Dan Sheep on the Kenai Peninsula are all the result of transplants. To the west the area is essentially isolated from the interior and Beringia by the Kenai Mountains, Cook Inlet, Shelikof Strait, and the mountain and glacier system of the Alaska Peninsula. To the east it is isolated by Bering Glacier, Icy Bay, and Malaspina Glacier. To the north it is isolated from the interior by the mountains, glaciers, and icefields of the Chugach Range. Limited communication to the interior might have existed down the Kenai Peninsula or via the Copper River valley, though neither would have provided easy access. Even if access to the interior was available, there is no evidence that the large Pleistocene mammalian fauna characterized by horse, bison, mammoth, and associated species such as occupied Beringia and the Yukon-Tanana valleys ever existed south of the Alaska Range.

Without evidence to the contrary then, it must be assumed that no large terrestrial mammals except mountain goat, brown bear, and black bear occupied the region south of the Chugach Range, east of the Kenai Range, and west of Cape Suckling prior to the transplants of this century. Moose, mountain goat, brown and black bear, and possibly caribou and bison may have occupied the Kenai Lowlands-Cook Inlet locality, at least during the last half of the time sequence. Even this Kenai-Cook Inlet area was probably devoid of most of the large Pleistocene mammal fauna which characterized Beringia.

While there is virtually no supportive paleontological evidence, it may be assumed with relative safety that the nearshore marine environment hosted at least two pinniped marine mammals (spotted seal and Steller sea lion) , probably sea otter, and various cetaceans of the North Pacific region. Coastal resources probably also included anadromous and marine fish, rooking marine birds, nesting and migrating waterfowl, and marine invertebrates such as clams, mussels, limpets, scallops, urchins, crab, and-shrimp. Most, or all, of these resources may have been in short supply during the first half of the period, depending on environmental conditions.

Coastal marine resources might have expanded rapidly, and significantly, once the climate moderated and glacial retreat began (probably after 12,000 B.P.). During the "climatic optimum" warm interval, somewhere between 9,000 and 3,000 B.P., such marine coastal resources might have been particularly abundant. Those most attractive to subsistence hunters might have been anadromous fish, pinniped marine mammals, sea otters, rooking marine birds, and intertidal invertebrates. During this warm hypothermal it is also possible, though unsubstantiated by paleontological data, that one other pinniped species, the northern elephant seal, might have expanded its range northward to include this area. It is also possible that the Steller sea cow might have penetrated into the Prince William Sound area.

Synthesis and Synopsis of Sequences

Based on the above discussion and literature sources, six environmental shifts are proposed for the Cook Inlet-Prince William Sound region. These will be discussed sequentially by time period. A brief synopsis in tabular form is presented in Table II-2.

1. 20,000-13,000 B.P.

There is considerable controversy over conditions which may have prevailed during this period, particularly as regards the extent of glaciation. If, as some authors feel, the entire area was heavily glaciated to the limits of the continental shelf, then vegetational and faunal resources would have been virtually non-existent. If such glaciation did not extend onto the continental shelf to any great degree, then at least marginal subsistence resources might have been available.

The climate during this period is generally agreed on as cold and dry, though presumably less cold than during the glacial maximum of 25,000-20,000 B.P. A tundra or tundra-steppe vegetational regime is hypothesized for this phase, probably with some willow and alder growth in the lowlands and along stream valleys.

Terrestrial faunal resources were probably minimal during this period. Probably no large mammal species, with the possible exception of brown bear and mountain goat, existed at all southeast of the Kenai Mountains. Moose, and possibly caribou and bison, may have inhabited the Cook Inlet region northeast of the Kenai Range, though this is uncertain.

Marine resources might have been more abundant, though considerable uncertainty exists as to species composition, distribution, and density. Primary reliance might have been placed on anadromous fish, pinniped marine mammals (harbor seal and Steller sea lion), intertidal invertebrates, and marine rooking birds. Coastal ice, lowered salinity, and turbidity conditions resulting from the melting glaciers might have compromised the carrying capacity of the nearshore environment for such resources, though this is uncertain.

2. 13,000-11,000 B.P.

This period almost certainly saw a major climatic reversal, from cold and dry to warm and wet, accompanied by rapid glacial retreat. The vegetational regime probably altered accordingly, with willow, alder, and perhaps spruce forest replacing, in part at least, the tundra and tundra-steppe habitat hypothesized for the preceding period.

Terrestrial resources probably did not improve significantly during this phase, though marine ones might have. Moderated climatic and ice conditions might have favored increased populations of anadromous fish, pinniped marine mammals, marine invertebrates, and marine rooking birds. Such increases would probably have been felt particularly in the Prince Wiliam Sound area, along the southeast Kenai Peninsula coast, and along the Cook Inlet coast of the Kenai Peninsula south of Kachemak Bay.

3. 11,000-10,000 B.P.

This interval is generally described as a return to the cold dry climate similar to the 20,000-13,000 B.P. period. It is assumed that this climatic reversal was reflected in vegetational patterns, probably resulting in expanded tundra habitat at the expense of spruce, alder, and willow.

Faunal resources might or might not have been greatly affected by this climatic shift. Certainly they could not have been improved.

4. 10,000-9,000 B.P.

This is thought to be an interim period of gradual climatic amelioration, becoming slowly warmer and wetter. Little can be said about vegetational changes other than assuming that, with this climatic moderation, spruce, willow, and alder probably once more began replacing tundra as the dominant habitat. Similarly, there were probably no drastic alterations in faunal resources, though the improving climate might have resulted in a gradually expanded carrying capacity.

5. 9,000-3,.000 B.P.

This period probably saw the most drastic environmental changes. In climatic terms this was a period of major reversal, from cool or cold to quite warm and probably wet. Temperatures probably rose steadily throughout this period to the "climatic optimum" or hypothermal somewhere between 7,000 and 3,000 B.P. It was probably a period of rapid glacial retreat, culminating in a relative stabilization of sea level at about 7,000 B.P. (Curray 1965).

Vegetational patterns probably underwent considerable alteration during this period, evolving into a primarily forest habitat composed of spruce, hemlock, willow, alder, and birch.

Faunal compositions also may have undergone some significant changes during this period. In the terrestrial realm, it is probable that even during this climatic optimum no large mammal species other than mountain goats and brown and black bear penetrated into the Prince William Sound enclave between the Kenai Range and Cape Suckling. Populations of these species, however, as well as small mammals, wildfowl, and freshwater fish, might have expanded considerably. In the Cook Inlet area, caribou and moose, and possibly bison, might also have provided a significant terrestrial resource.

Marine resources might have been considerably expanded during this phase. This is particularly true for anadromous fish, marine mammals, rooking marine birds, and intertidal invertebrates. As the climate warmed and sea level rose, the marine habitat probably expanded correspondingly in diversity, productivity, and carrying capacity. In addition to the species occupying this region at present, it is possible that two other marine mammal species of potential resource importance, the northern elephant seal and Steller sea cow, also expanded their range into at least Prince William Sound at this time.

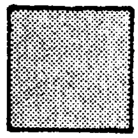
6. 3,000 B.P.-Present

This period, following the climatic optimum, was one of cooling temperatures. Changes in vegetation patterns were probably fairly subtle, resulting in the dominant spruce/hemlock forest habitat seen today over most of the area. Faunal resources probably declined somewhat through this final period due to the overall worsening of climatic conditions and to the possible extinction or evacuation of the area by the northern elephant seal and Steller sea cow.

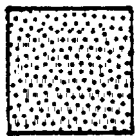
DISCUSSION OF PALEOECOLOGY AND RESOURCE DISTRIBUTION BY STILLSTAND

During the Late Wisconsin transgression, six stillstands or periods of relative stability in sea level are hypothesized (Sharma 1977). These stillstnads appear to have occurred at -125 m (21,500-18,000 B.P.), -82 m (15,000-14,800 B.P.), -66 m (13,750 B.P.), -55 m (12,700 B.P.), -38m (9,400 $\pm$ 220 B.P.), and -28m (8,700 B.P.).

In the following section, probable paleoclimatology and faunal resource distributions will be discussed for each of these" six still-stands, beginning with the earliest. Marine and terrestrial faunal distributions are represented for each stillstand by symbols defined in Figure II-1.

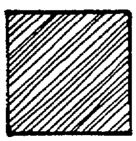


Probable seasonal concentrations of anadramous fish and their predators.



Probable concentrations of marine mammals and/or generally elevated nearshore marine productivity, diversity, and availability.

Passes or constrictions funneling movements of large terrestrial mammals.



South or north facing slopes providing possible spring and fall attraction to large herbivores.

Figure II-1. Key to Symbols Used for Probable Marine and Terrestrial Faunal Distribution (Figures II-2 through II-25).

Stillstand I: 21,500-18,000 B.P.

At -125 m, this stillstand represents the maximum extent of Late Wisconsin glaciation and, correspondingly, the maximum sea level recession. This recession would have exposed a considerable portion of the marine continental shelf, including most of Cook Inlet and large areas between Montague Island and Cape Suckling (Figures 11-2 to 11-5). At this maximal recession, Prince William Sound would have been much reduced in area, with access to the Gulf of Alaska restricted to fairly narrow channels through Hinchinbrook Entrance and Montague Strait.

Unfortunately, there is considerable lack of agreement, as discussed earlier, concerning t-he extent of glaciation in this region during the Late Wisconsin. Since no resolution of that question is possible at this time, probable resource distributions will be considered in the light of minimal glaciation. Extrapolating from present bathymetry, the emergence of two very large peninsulas is indicated for the eastern half of the study region, separated by a deep trough to the west of Kayak Island. Montague Island would have been greatly expanded to the south and east, and three additional large islands would have been exposed off the southeast coast of the Kenai peninsula (Figures 11-3 and II-4). Most of the projecting headlands of this southeast coast would themselves have been expanded to form several peninsulas or sub-peninsulas of considerable size, and the main Kenai Peninsula would have been extended to encompass the Barren Islands to the southwest. The Kenai Peninsula itself, in fact, would hardly be a peninsula during this period since virtually all of Cook Inlet, including Kachemak Bay, would have been emergent. The very large lake indicated between the present end of the Kenai Peninsula and the Barren Islands might have been a large marine embayment rather than a freshwater lake since the sills separating it from the Gulf of Alaska would have been so low as to allow possible communication with the sea.

The weather during this period was probably colder and drier, and generally more severe than at present. The vegetational

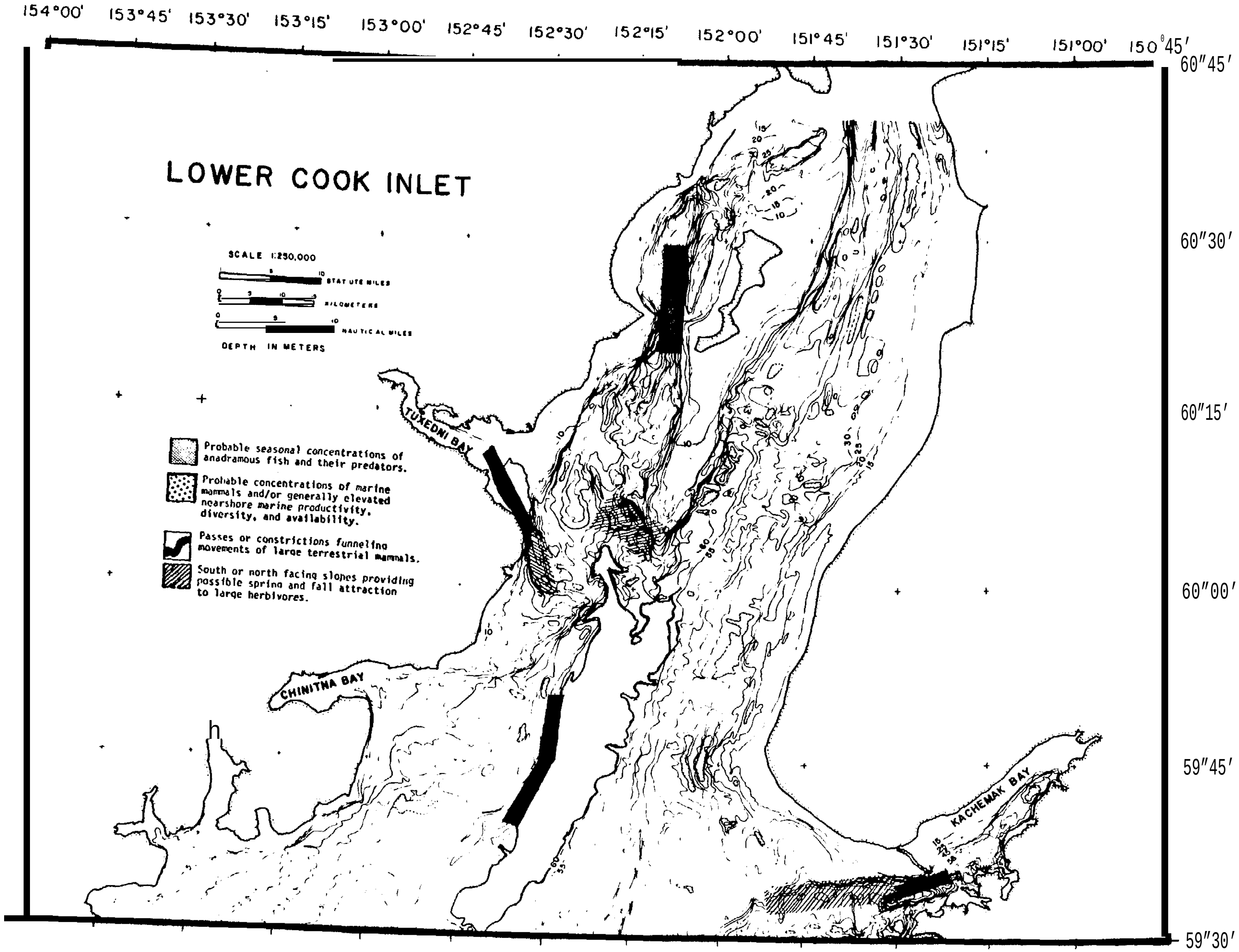


Figure II-2. Stillstand I with shoreline at -125 m, 21,500-18,000 B.P. Lower Cook Inlet: Kalgin Island to Kachemak Bay.

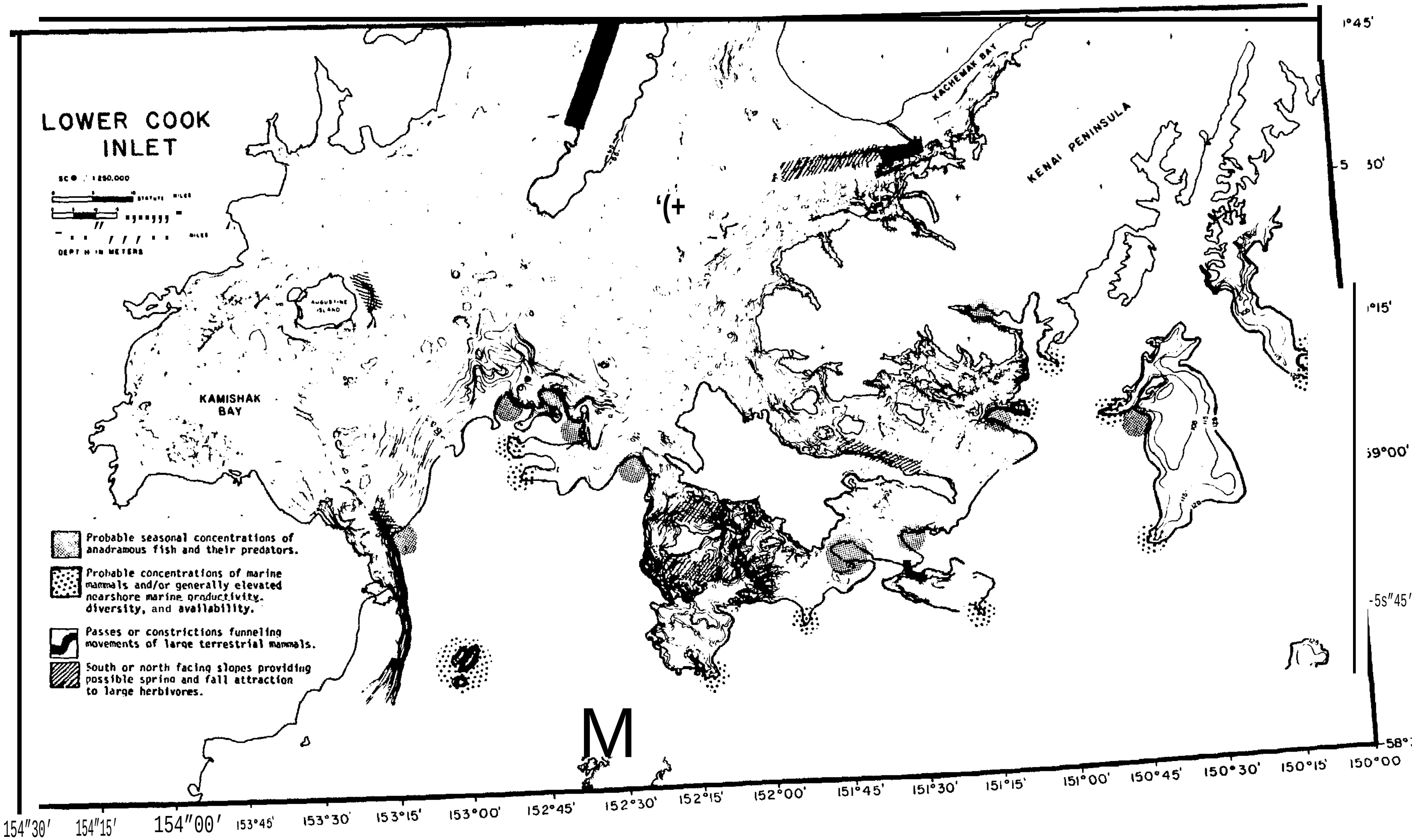


Figure II-3. Stillstand I with shoreline at -125 m, 21,500-18,000 B.P. Lower Cook Inlet: Kamishak Bay through Kennedy Entrance to Two Arm Bay.

regime on emergent portions of the continental shelf was probably that of a cold tundra or tundra-steppe environment, though any statement about vegetational regimes during this period are conjectural in the extreme. None of the pollen cores so far examined from the area date beyond 11,000 B.P., and all are from presently terrestrial areas.

Terrestrial resources within Cook Inlet and Kachemak Bay to the west of the Kenai Peninsula might have been sufficient during this time period to support subsistence economies. Depending on the extent of glaciation, this emergent shelf might have provided habitat for moose, caribou, and perhaps bison. The evidence for bison is extremely tenuous, however, and restricted to one find of fairly recent age in the Anchorage vicinity (R. D. Guthrie, Univ. of Alaska, vive vote). Aside from this one specimen, there is no evidence that the large grazing populations (mammoth, horse, bison) which inhabited Beringia and the Alaskan interior during this period ever penetrated south of the Alaska Range.

Large mammal resources were probably quite restricted during this and all subsequent time periods for the region lying east of the Kenai Mountains and Kennedy Entrance. With the exception of brown bear, black bear, and mountain goat, there is no evidence that any large mammal populations have inhabited this region during glacial or post-glacial times. During this period of maximum glaciation and climatic severity, the ranges and populations of even these few species was probably reduced or nonexistent. Wildfowl and other birds, small terrestrial mammals, and freshwater fish might have provided limited resources but probably could not have provided the basis for a year-round subsistence economy.

Marine resources might have provided a more reliable subsistence base, though even these resources were probably more restricted than is presently the case. Anadromous fish (primarily salmon) are presently a major biotic resource of the region, both in Cook Inlet and Prince William Sound. Depending on glacial conditions, this might also have been true during the Late Wisconsin. With the exception of a few localities, however, it is impossible to define with even the remotest degree of confidence where such anadromous fish runs might have concentrated during these early periods.

Another considerable resource potential, particularly east of the Kenai Peninsula, might have consisted of marine mammals during this and succeeding periods. During this early phase it seems probable that marine mammal species would have been limited to cetaceans and to no more than two pinnipeds (harbor seal and Steller sea lion). Again, both species composition, distribution, and density would depend to a great extent on glacial and sea ice conditions. Harbor (spotted) seals seem, presently at least, to be quite adaptable to sea ice and even to congregate in the vicinity of tidewater glaciers along this coast. The same is not true, however, of Steller sea lions, which appear to avoid ice. Areas of concentration for pinniped marine mammals, particularly harbor seals, would be river mouths and estuaries attracting anadromous fish, projecting spits, headlands and islands, and zones of enhanced marine productivity. The outer peninsular and island beaches in the eastern sector might have been very attractive considering their proximity to the steep continental slope. Upwelling conditions, promoting enhanced productivity, probably occurred along this slope. Such upwelling zones might also have attracted concentrations of cetaceans, though whether or not they would have been available as prey to early human hunters is a matter of speculation.

Intertidal invertebrate resources, with the possible exception of bivalve mollusks, were probably in short supply during this period as a result of general climatic severity, coastal ice scouring, and salinity/turbidity conditions. Even if glaciation did not itself extend over this exposed shelf, calving from tidewater glaciers and seasonal sea ice resulting from increased climatic severity probably kept intertidal invertebrate populations suppressed, as it presently does in the Bering and Chukchi seas. Glaciation probably increased the turbidity of the near-surface water to a considerable degree also, thus decreasing light penetration and primary productivity levels in the nearshore zone. As glacial withdrawal began, this turbidity problem would have been exacerbated and compounded by lowered surface salinities, further suppressing primary productivity and intertidal resources.

In general terms, the resource potential of the region as a whole would not appear to be particularly encouraging to subsistence economies during this time period, though a few locales might have presented sufficient potential. One of these is the Barren Islands vicinity, which at that time was emergent and connected to the Kenai Peninsula. The topography of this area would have offered opportunities for approaching and ambushing large mammals (moose, bison, caribou) which may have frequented that portion of the emergent shelf. In addition, it probably would have presented resource potential in the form of marine mammals and anadromous fish and would have been adjacent to the large lake or lagoon just south of the Chugach Islands.

Another area offering possible potential during this still-stand might have been in the vicinity of central lower Cook Inlet west of Kennedy Entrance. This locale might have been favorable for anadromous fish, marine mammal (harbor seal, beluga whale) , and terrestrial mammal (moose, caribou, bison) resources. The topography of several other localities within Kachemak Bay and upper Cook Inlet (Figure II- 3) might have created pass or funneling situations attractive to hunters of large terrestrial mammals.

Stillstand II: 15,000-14,800 B.P.

At -82 m below present level, the encroaching sea would by this time have greatly shrunk the large peninsula previously adjoining Montague Island, opened a channel between Hinchinbrook Island and the peninsula which formerly adjoined it, flooded the shallow sill between the Kenai Peninsula and the Barren Islands, and begun pushing the shoreline back into Cook Inlet (Figures II-6 to II-9).

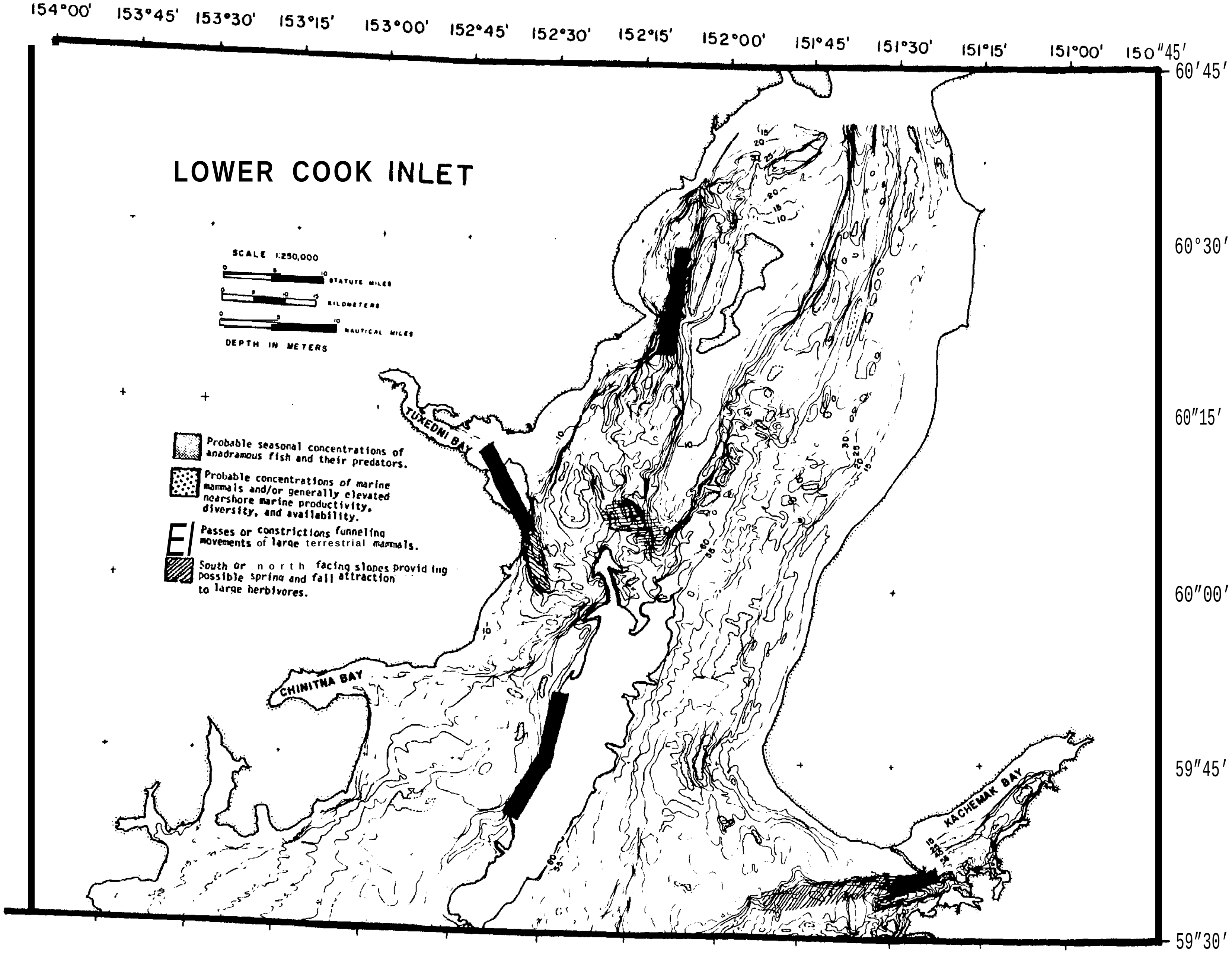


Figure II-6. Stillstand II with shoreline at -82 m, 15,000-14,800 B.P. Lower Cook Inlet: Kalgin Island to Kachemak Bay.

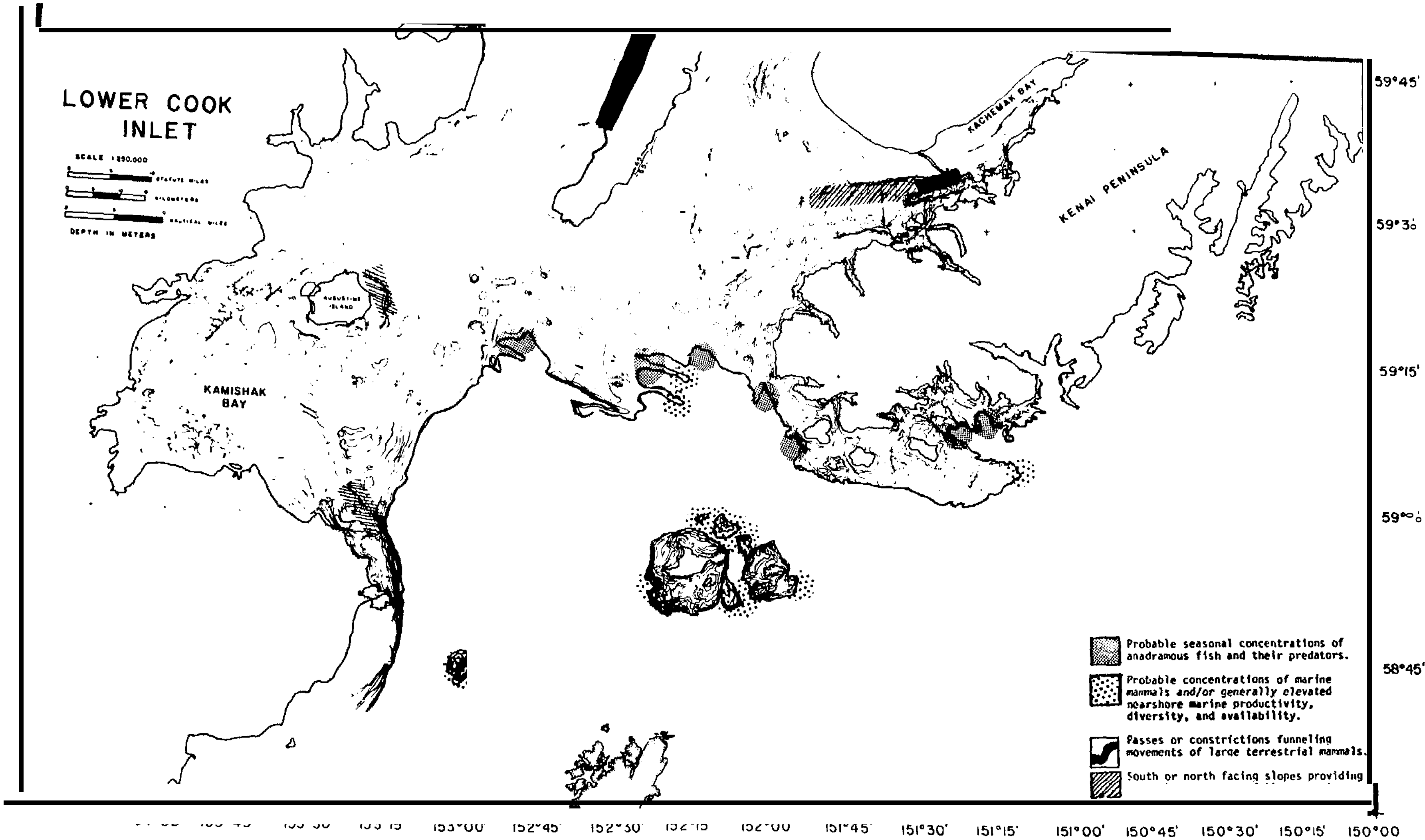


Figure I-7. Stillstand II with shoreline at -82 m, 15,000-14,800 B.P. Lower Cook Inlet: Kamishak Bay through Kennedy Entrance to Two Arm Bay.

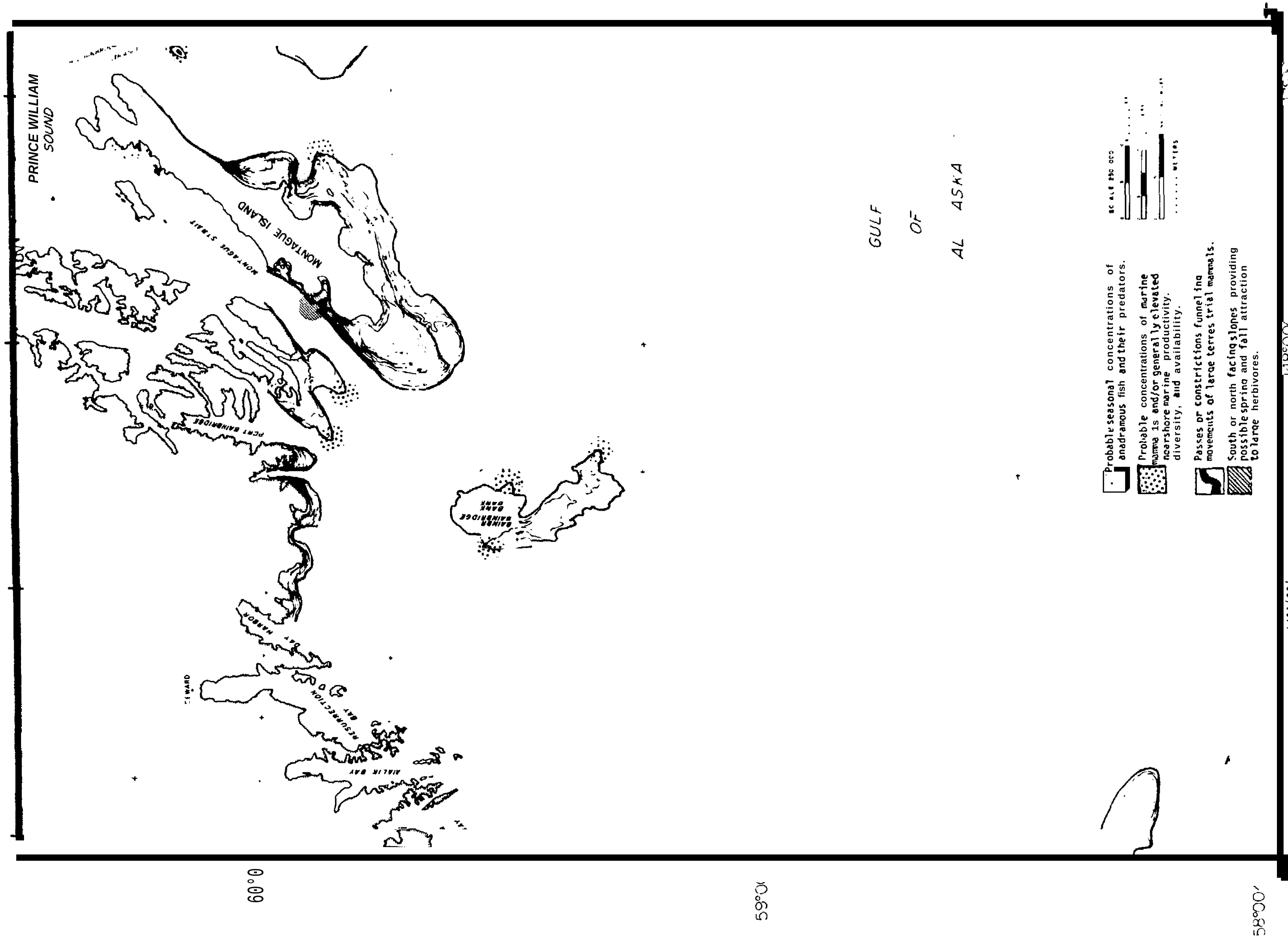


Figure II-8. Stillstand II with shoreline at -82 m, 15,000-14,800 B.P. Two Arm Bay to Montague Island.

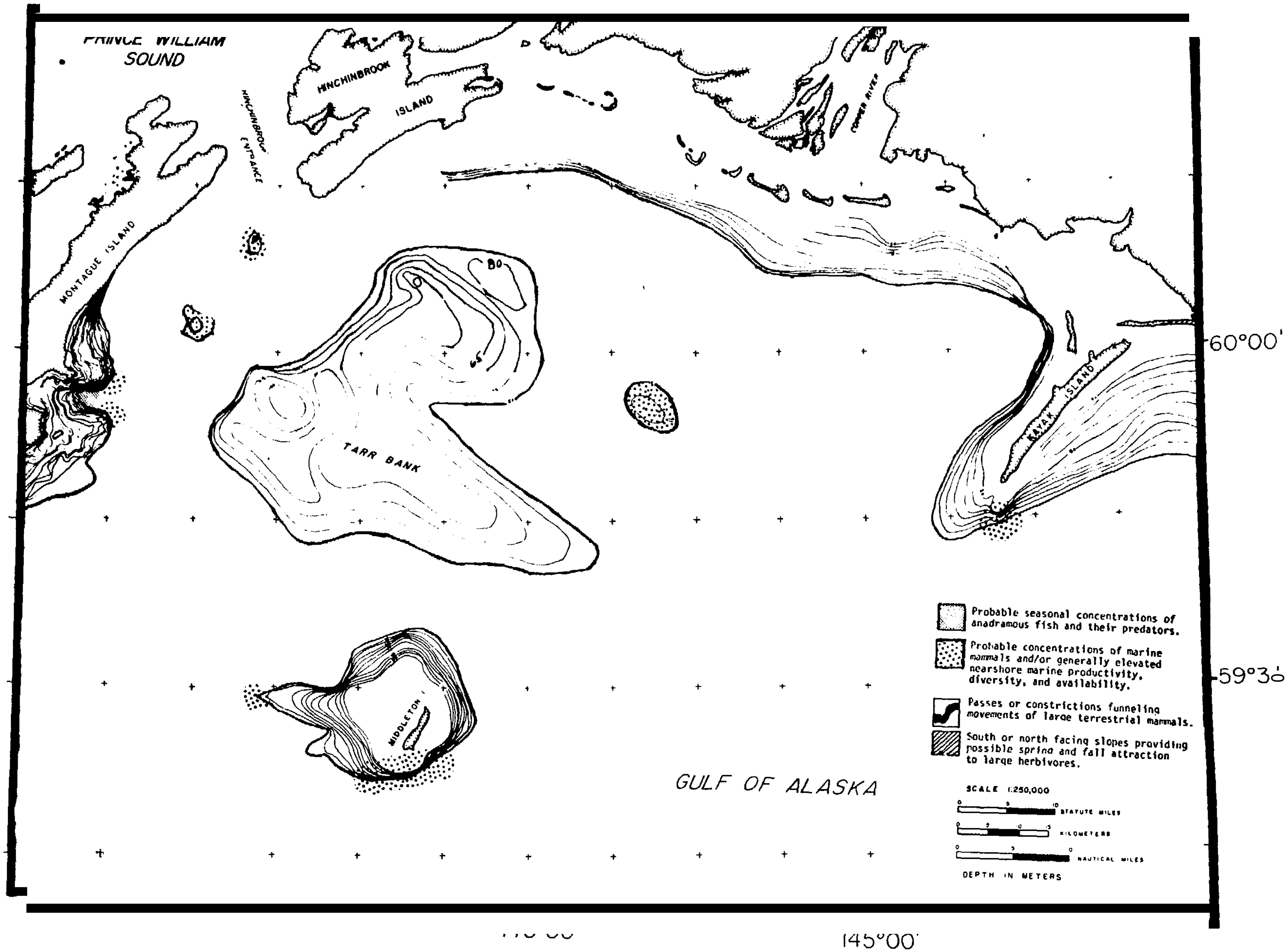


Figure II-9. Stillstand II with shoreline at -82 m, 15,000-14,800 B.P. Island to Kayak Island and Cape Suckling

The climate at this time, considering the evidence of glacial retreat, was probably somewhat warmer than during the glacial maximum, though probably still at least as severe as at present. Terrestrial vegetation, from the scanty evidence available, is still hypothesized as primarily tundra or tundra-steppe for this period (Table II-2) , perhaps with some encroachment of willow, alder, and spruce in favorable areas.

Terrestrial resources over the region in general were probably no more abundant than during the preceding stillstand. The ameliorating climate might have improved conditions for some species, such as moose and caribou, over the Kenai lowlands and emergent portions of Cook Inlet, but rising sea level would at the same time have reduced by a significant amount the available range. The flooding of Kennedy Entrance, between the Kenai Peninsula and the Barren Islands, would also have isolated one of the more potentially productive terrestrial are as.

In terms of marine resources, however, conditions were probably at least as favorable as during the earlier stillstand, and might have fostered the expansion, in terms of both range and population, of at least two marine mammal species important to the area (Steller sea lion and sea otter) , and would probably have had no ill effects on the range and population of the harbor (spotted) seal. The improved climate might also have led to range and population expansion by avian populations, particularly marine rooking birds.

The situation concerning anadromous fish and marine intertidal invertebrates during this period is highly speculative. Warmer temperatures and glacial retreat might have led to increased resources in both categories. The increased turbidity and, in the case of intertidal invertebrates, lowered salinity which must have resulted from this glacial wastage might, on the other hand, have largely nullified such beneficial effects. Such turbidity and salinity effects would have been particularly deleterious to intertidal invertebrate populations of interest as subsistence resources, and might have resulted in lowered nearshore marine productivity in general over the region.

As for the previous stillstand, passes and constructions on the emergent shelf of Cook Inlet might have been favorable sites for hunters of terrestrial mammals. The coastal zone of central Cook Inlet might, in addition to terrestrial resources, have provided anadromous fish and marine mammals (Figures II-6 and II-7).

Viewing marine resource potential, any of the bays and river mouths of the southeastern coast of the Kenai Peninsula might have been favorable for anadromous fish, marine rooking birds, and marine mammals, as would those of the major islands. Capes, headlands, and islands would also have tended to concentrate marine mammals and birds. Steller sea lions, sea otters, and rooking birds would have tended to favor the steeper, rocky headlands and islands, while harbor seals probably tended to congregate more on areas of lower relief with sandy beaches. In all cases, areas adjacent to possible upwelling zones, such as along the continental slope, might have provided enhanced productivity. Unfortunately, problems with bathymetric definition make it virtually impossible to detail such areas of probable high resource potential with any great degree of confidence.

Stillstand III: 13,750 B.P.

By this time the sea had risen to the -66 m (below present) level, flooding most of the formerly emergent islands, peninsulas, and adjacent coastal areas east of the Kenai Peninsula. Lower Cook Inlet below Kachemak Bay would be submergent by now, as would outer Kachemak Bay itself (Figures 11-10 and 11-11).

The climate and vegetation during this period were probably not greatly different than during the preceding stillstand. The trend of gradual climatic amelioration probably continued, perhaps resulting in more widespread encroachment of willow, alder, and spruce into previously tundra habitats.

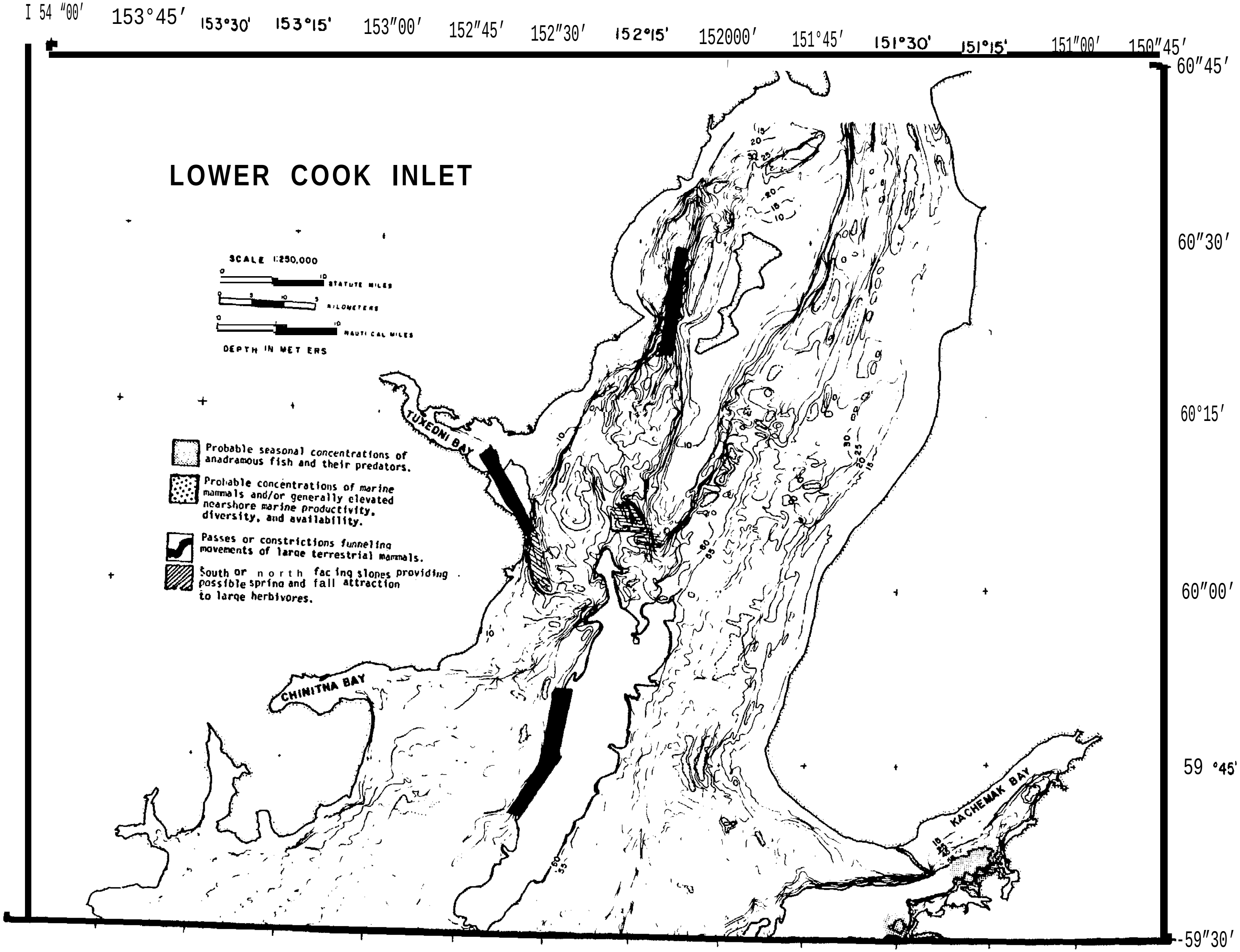


Figure II-10. Stillstand III with shoreline at -66 m, 13,750 B.P.
Lower Cook Inlet: Kalgin Island to Kachemak Bay.

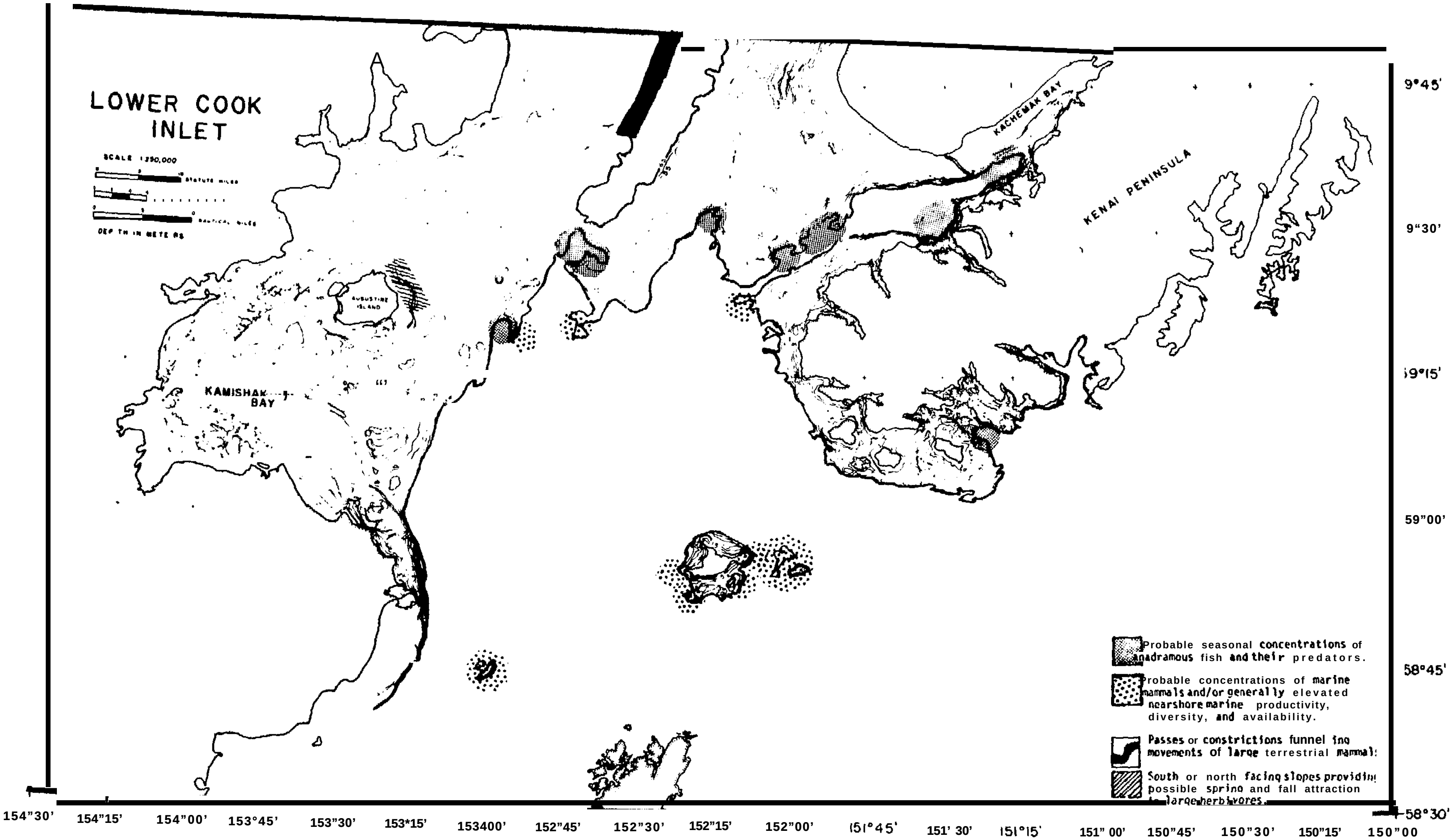


Figure II-11 Stillstand 111 with shoreline at -66 m, 13,750 B.P.
Lower Cook Inlet: Kamishak Bay through Kennedy Entrance
to Two Arm Bay.

Terrestrial resource potential would probably be about the same as for the earlier stillstand, though available range would be shrunken by the rising sea. As before, the Kenai lowlands and upper Cook Inlet would seem to present the only viable potential for an economy based on terrestrial mammal resources.

No great change would be expected in marine resource composition or availability, though rising sea level would have had some distributional effects. As before, primary marine resources might have been anadromous fish, marine mammals (Steller sea lion, harbor seal, possibly sea otter) , and marine rooking birds. River mouths, capes, headlands, spits, and islands would present the most likely concentrations of such resources, particularly those adjacent to upwelling zones (Figures 11-12 and 11-13).

Possible areas of enhanced potential would still be the terrestrial passes and constrictions of upper Cook Inlet, the bays and headlands of the lower Cook Inlet coast, perhaps some of the bays and headlands of the mainland and island coasts southeast of the Kenai Peninsula, and the Barren Islands if such were accessible to subsistence hunters at this time. In addition, the inlets and headlands of newly-flooded Kachemak Bay might have presented marine resource potential.

Stillstand IV: 12,700 B.P.

At -55 m below present level, the rising sea would by now have flooded the greater part of the continental shelf southeast of the Kenai Peninsula, and would have extended the shoreline far up Cook Inlet and Kachemak Bay (Figures 11-14 and 11-15).

The climate and vegetational regime by this time may have undergone considerable change. Data compiled by numerous investigators indicates a major worldwide climatic shift at about this time, from relatively cold and dry to warm and wet (Table II-2). This reversal, which probably lasted for about 2,000 years, probably resulted in widespread vegetational changes, with willow, alder, and spruce replacing in large part the tundra and grassland habitats of the previous periods.

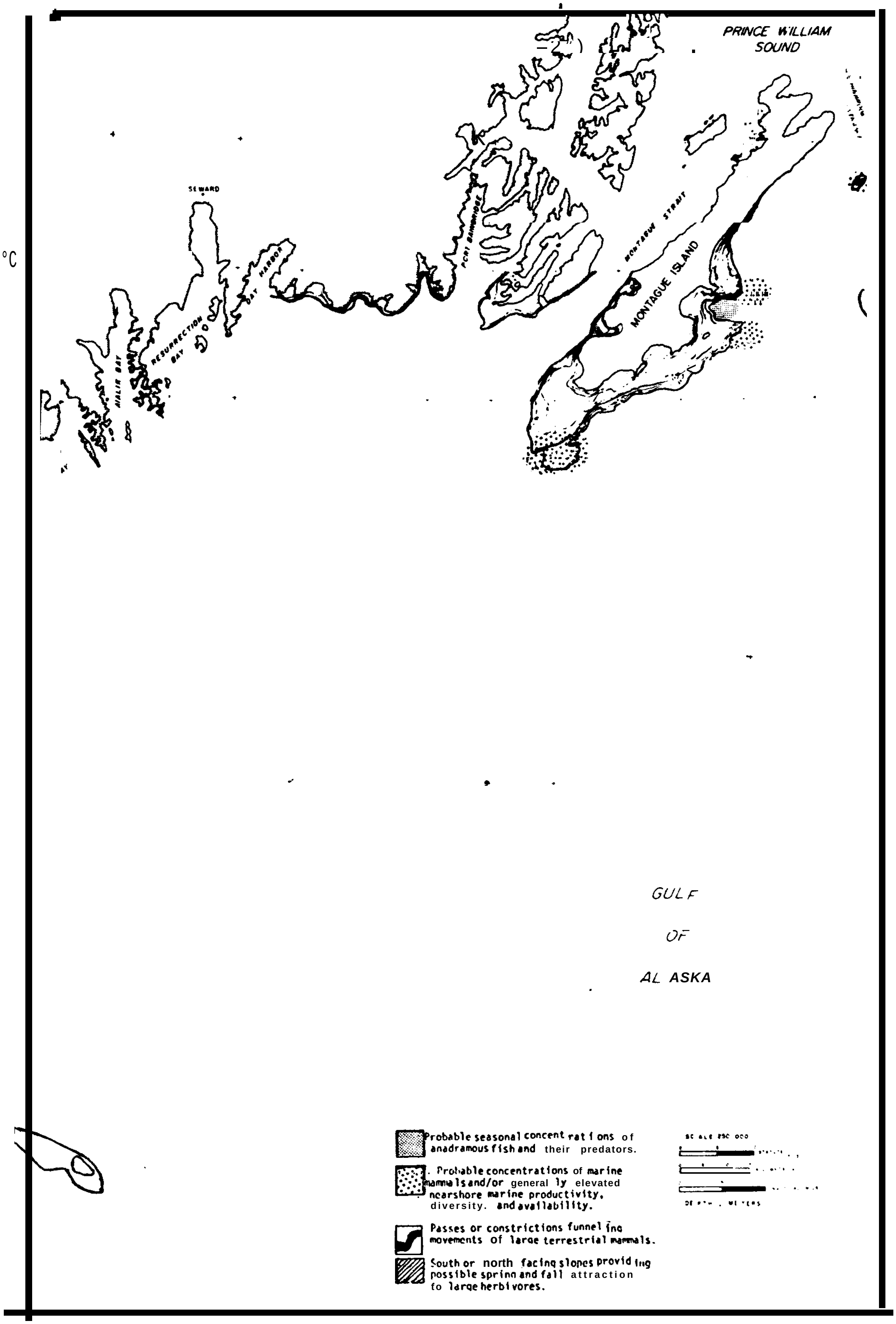


Figure II-12. Stillstand III with shoreline at -66 m, 13,750 B.P. Two Arm Bay to Montague Island.

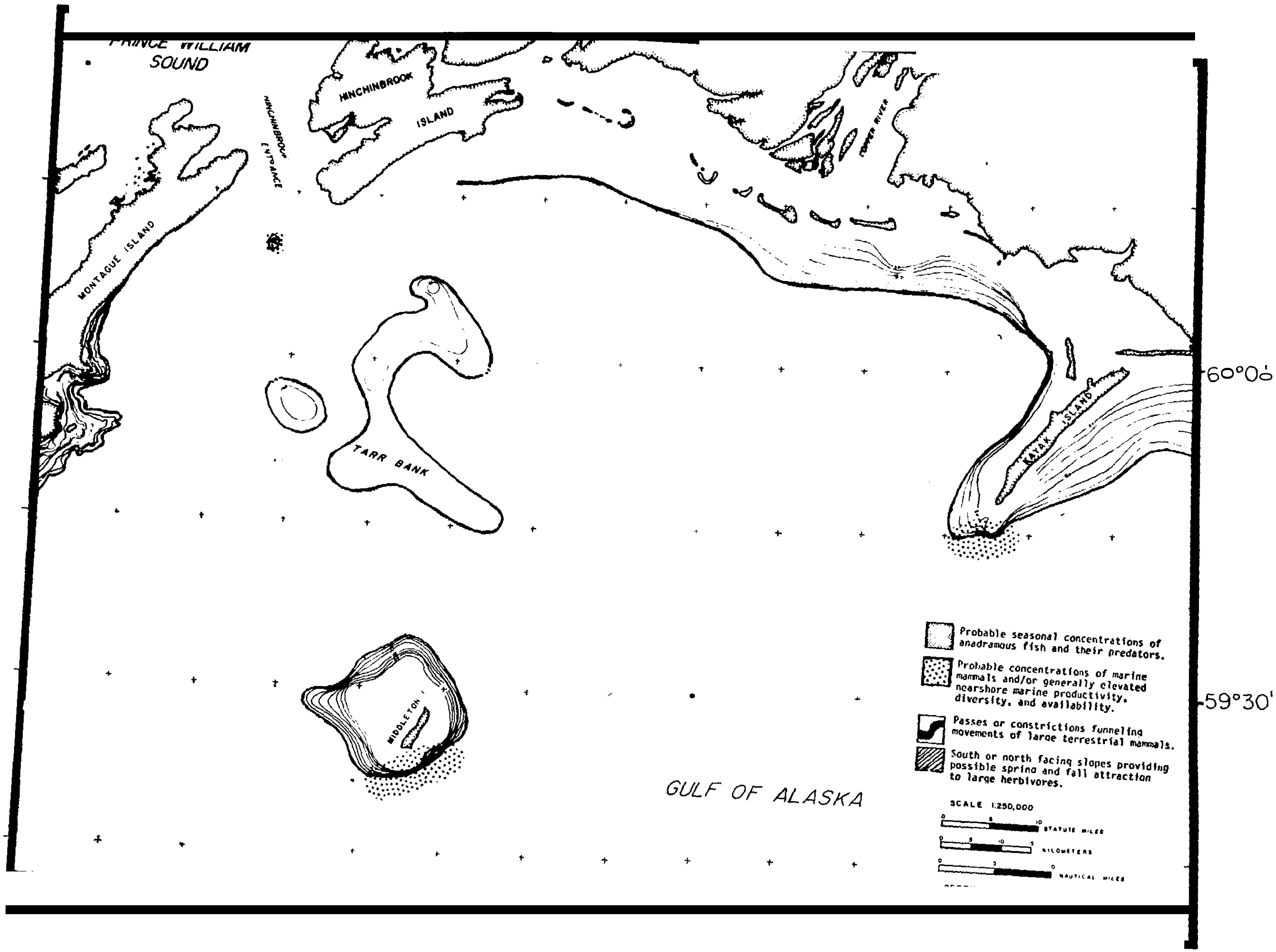


Figure II-13. Stillstand III with shoreline at -66 m, 13,750 B.P Montague Island to Kayak Island and Cape Suckling.

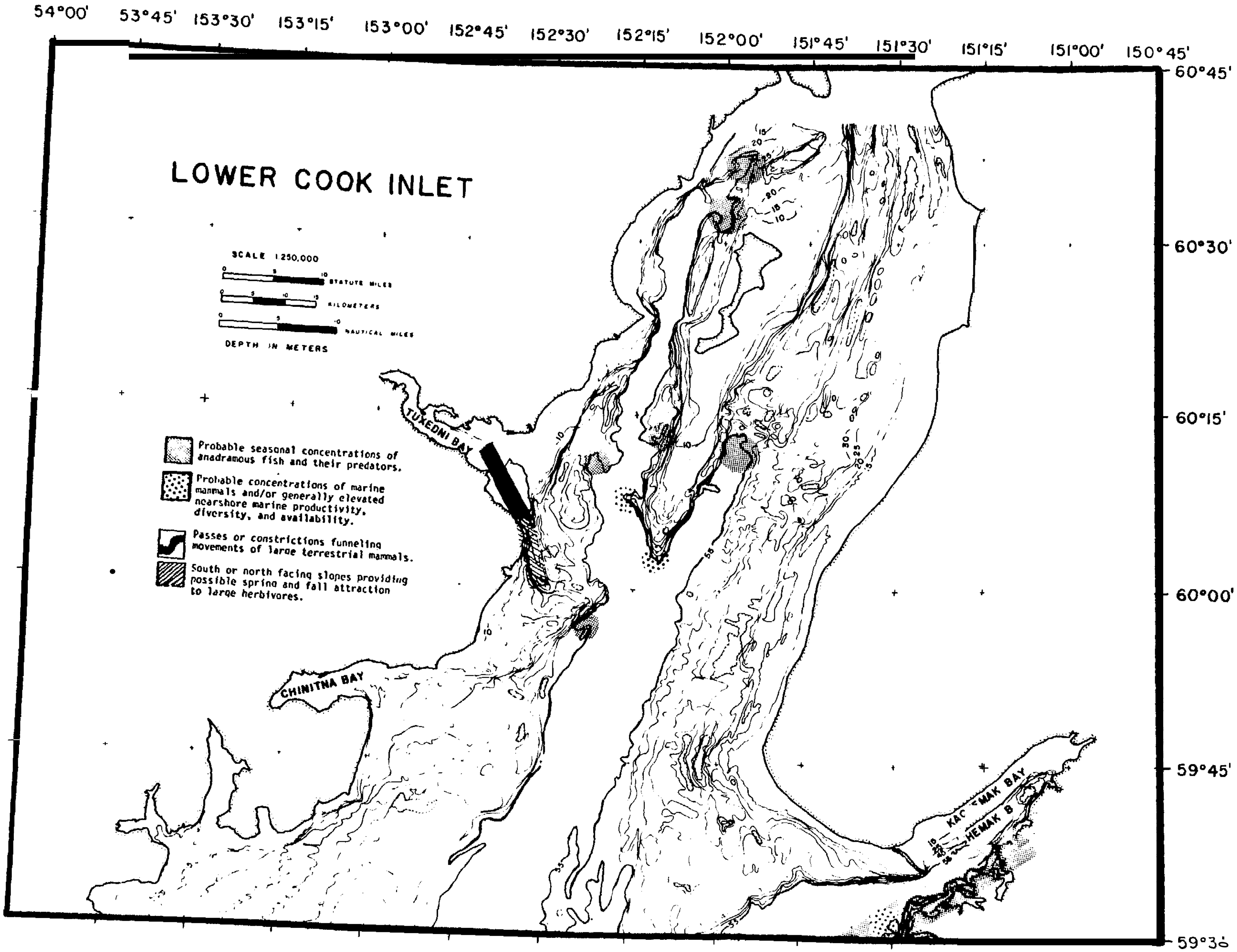


Figure II-14. Stillstand IV with shoreline at -55 m, 12,700 B.P. Lower Cook Inlet: Kalgin Island to Kachemak Bay.

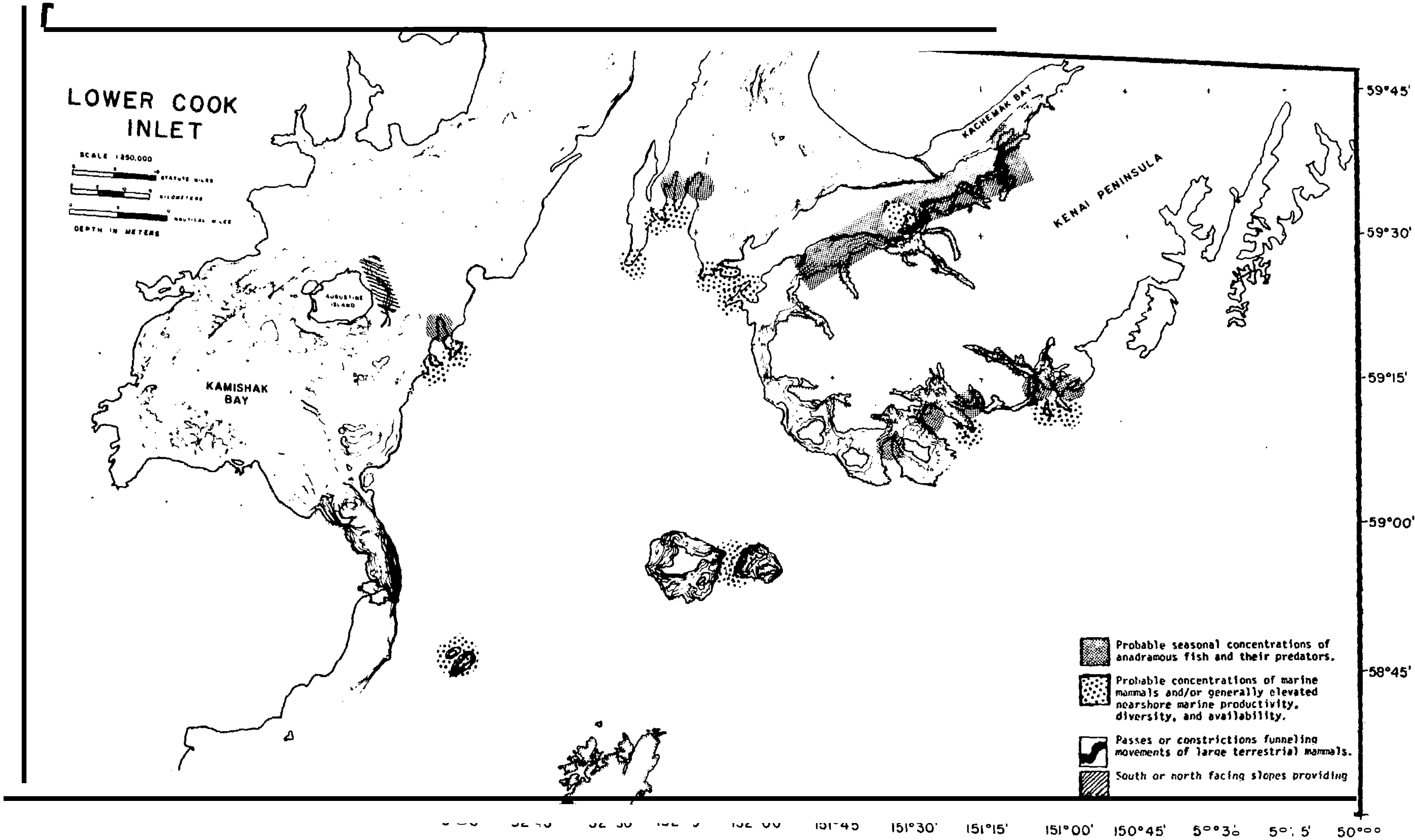


Figure II-15. Stillstand IV with shoreline at -55 m, 12,700 B.P. Lower Cook Inlet: Kamishak Bay through Kennedy Entrance to Two Arm Bay.

The flooding of the passes and constrictions of upper Cook Inlet probably resulted in considerable alteration of terrestrial large mammal distributions, and make it virtually impossible to delineate areas of potential concentration. The climatic and vegetational changes" must also have resulted in species compositional changes, with browsers such as moose probably expanding their distribution and population at the expense of grazers and tundra adapted animals such as bison and caribou.

Marine resources might have been more prolific and diverse during this period, though certain qualifying factors must be taken into account. Warmer water and sea temperatures, and a generally milder climate, might have resulted in increased populations of existing species such as Steller sea lion, harbor seal, and sea otter, and might have resulted in expansion into the region of other important marine mammal species, namely the northern elephant seal and Steller sea cow. Unfortunately, there is no paleontological evidence to support either assumption. Likewise, populations of marine birds, anadromous fish, and intertidal invertebrates might have benefited from this climatic change.

Other factors, however, shed some doubt on this extrapolation of generally increased nearshore resource potential. The sudden and major warming trend evidenced for about this time must have resulted in rapid glacial wastage, and the attendant turbidity and lowered salinity of the coastal zone might have inhibited both anadromous fish and marine primary productivity, thus affecting adversely all levels of the marine food chain.

Locales of probable marine resource potential would still be river mouths, islands, and projecting points of land throughout the region (Figures 11-14 to 11-17). Within Cook Inlet itself, Kachemak Bay and the smaller bays and headlands of the eastern side of the inlet would probably have been richer than those of the western due to considerations of current and salinity structure, as discussed earlier pertaining to present conditions.

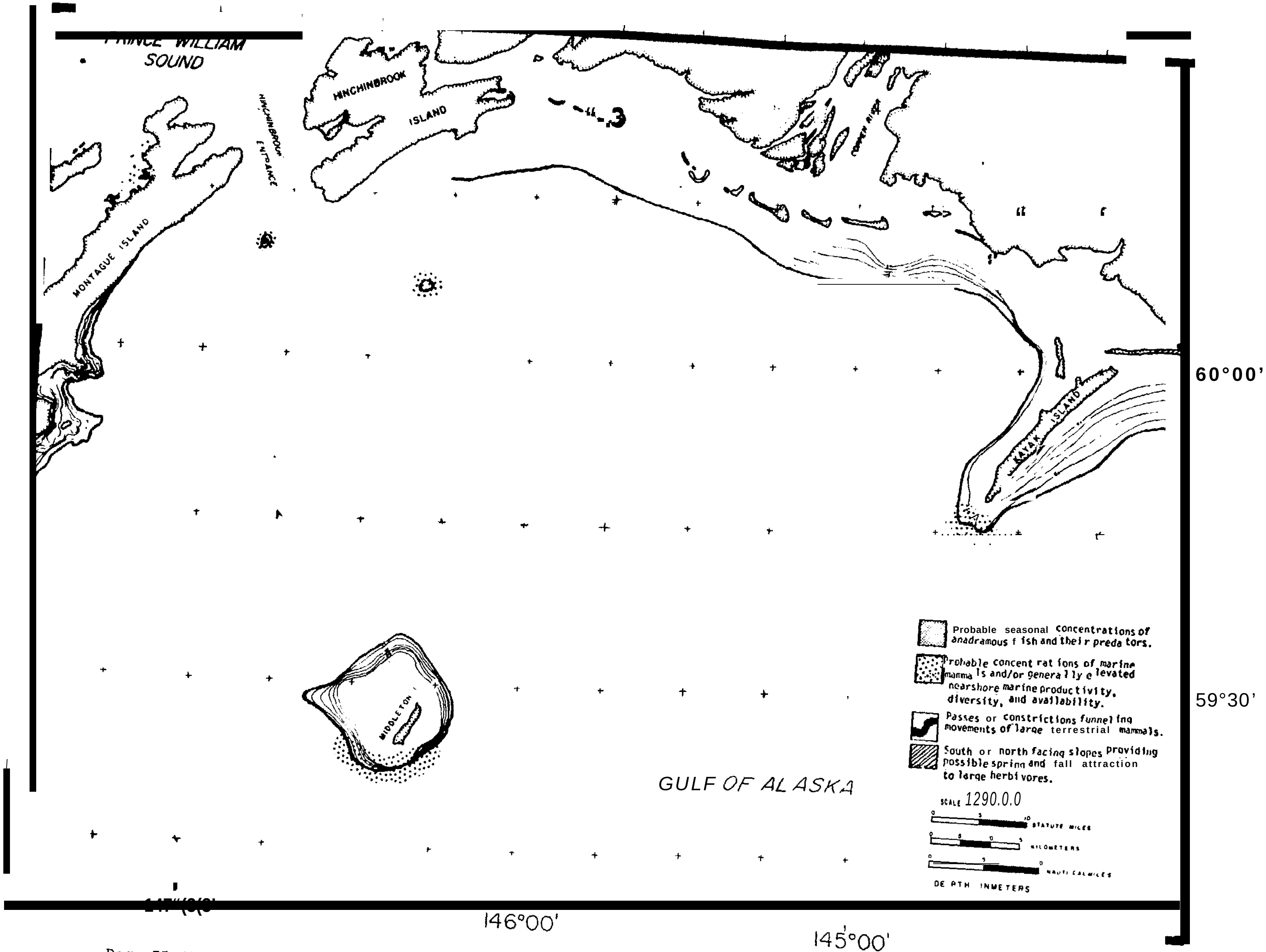


Figure II-16. Stillstand IV with shoreline at -55 m 12 700 B p Two Arm Bay to Montaque Island.

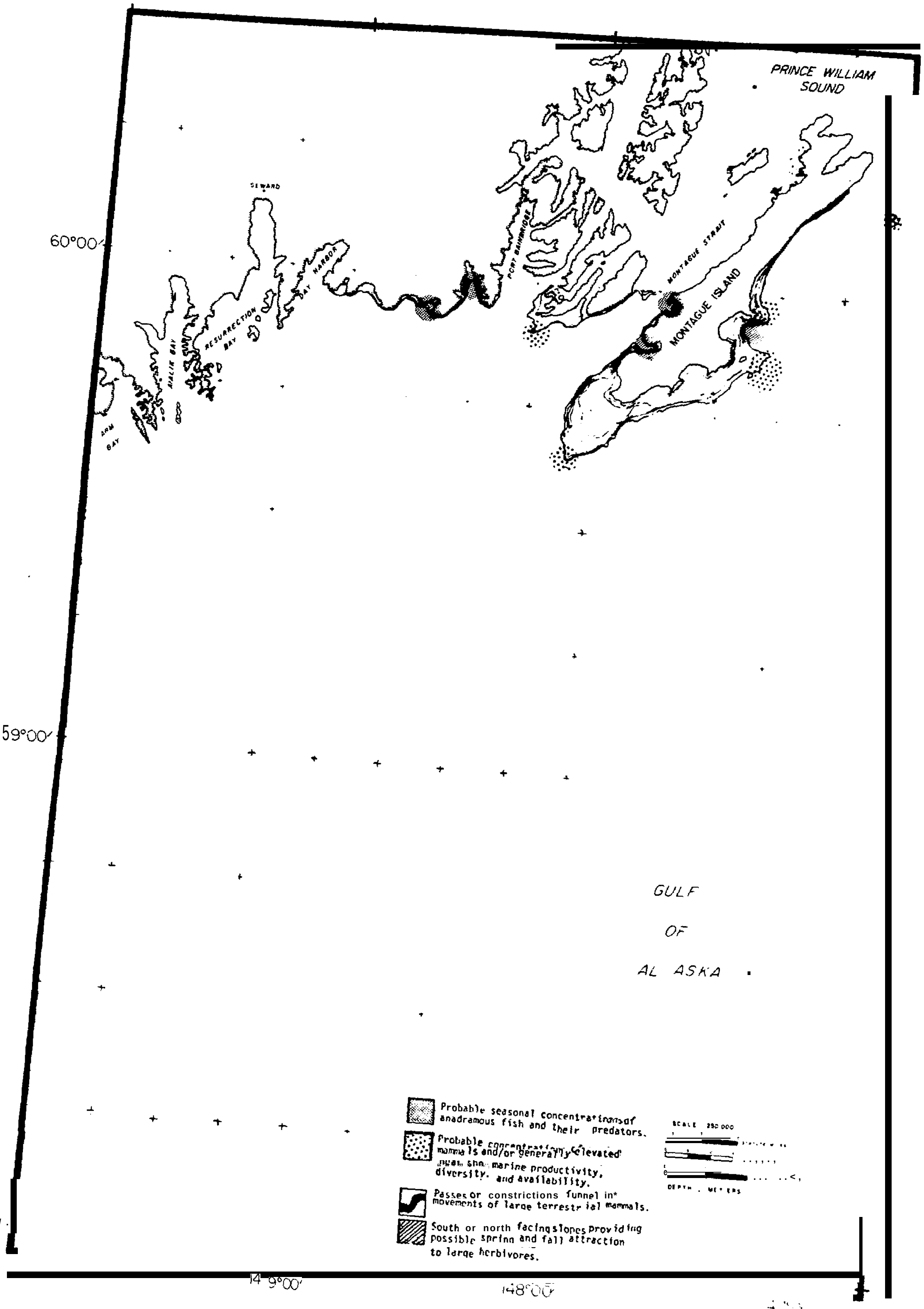


Figure II-17. Stillstand IV with shoreline at -55 m, 12,700 B.P. Montague Island to Kayak Island and Cape Suckling

Stillstand V: 9,400 ± 220 B.P.

By this time virtually all of the shelf adjoining the coast of Prince William Sound and the Kenai Peninsula east of Kachemak Bay was submergent once again. The only major emergent areas remaining by this time were in upper and western Cook Inlet, the Kayak Island-Copper River Delta vicinity, and the shelf adjoining Middleton Island (Figures 11-18 to 11-21).

From available data, it appears that this stillstand occurred near the beginning of a final Late Wisconsin or Early Holocene warm interval (Table II-2). Temperatures during this phase were at least as warm as at present and probably were warmer, with a vegetational regime of spruce, hemlock, and birch forest, interrupted in some regions by low muskeg bogs and perhaps grassland flats.

Terrestrial resources were probably not greatly different in species composition, availability, or distribution, from those observed over the region during historical times. For the Prince William Sound-Copper River region and the Kenai Peninsula coast south and east of Kachemak Bay, these resources were probably scanty--limited to mountain goat, brown and black bear, small mammals, birds, and freshwater fish. Moose, caribou, and possibly bison may have been available over the remainder of the Cook Inlet region, though areas of faunal concentration are impossible to delineate with any reliability.

Marine resources during this interval were probably about the same as during the previous stillstand, though distributions would have been altered locally due to the changing shoreline configurations. The areas of greatest potential might have been Kachemak Bay, the southeastern coast of the Kenai Peninsula, possibly some of the bays along the west side of Cook Inlet, and the Barren Islands if they were accessible to subsistence hunters at this time (Figure 11-19).

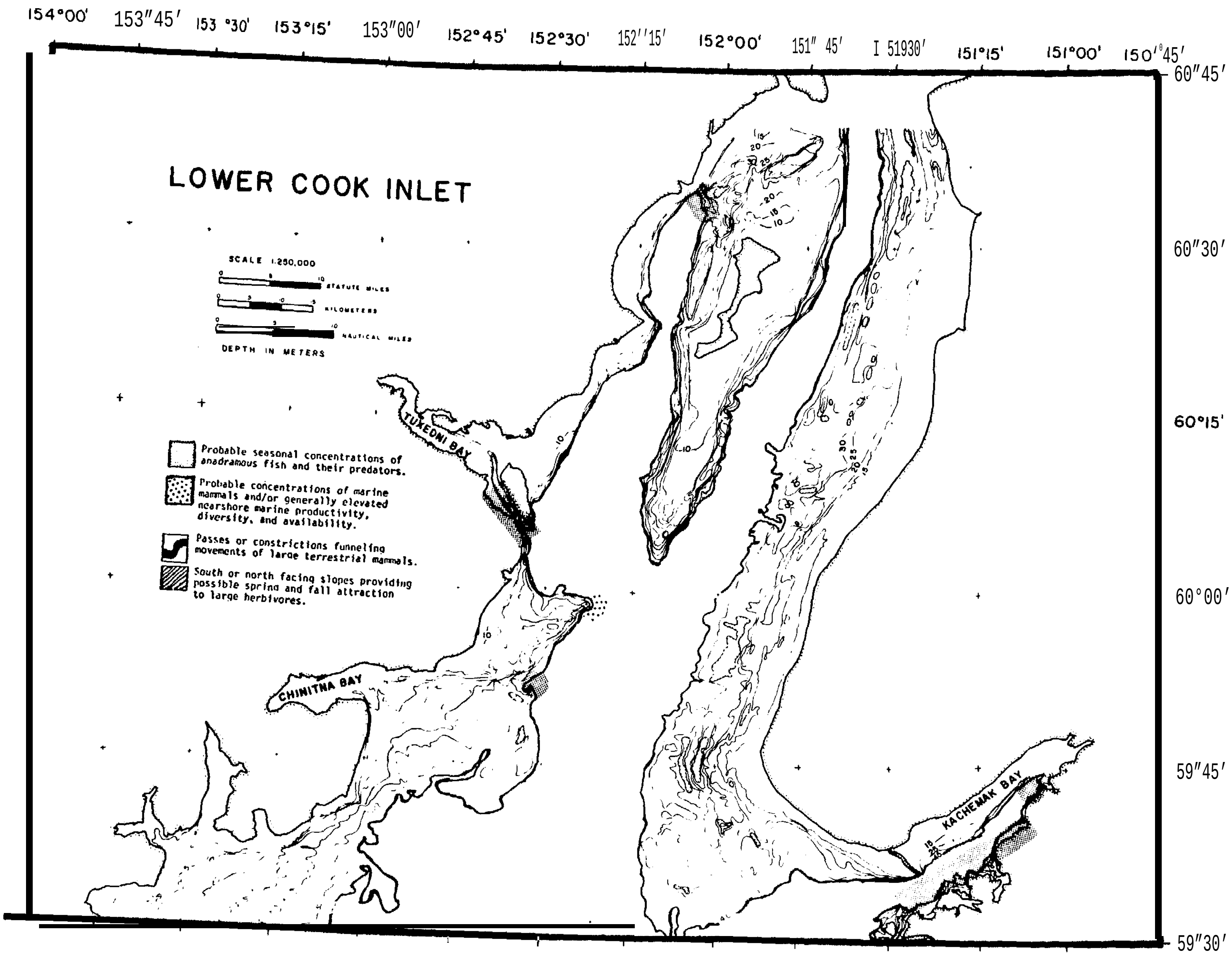


Figure II-18. Stillstand V with shoreline at -38 m, 9,400±220B.P.
Lower Cook Inlet: Kalgin Island to Kachemak Bay.

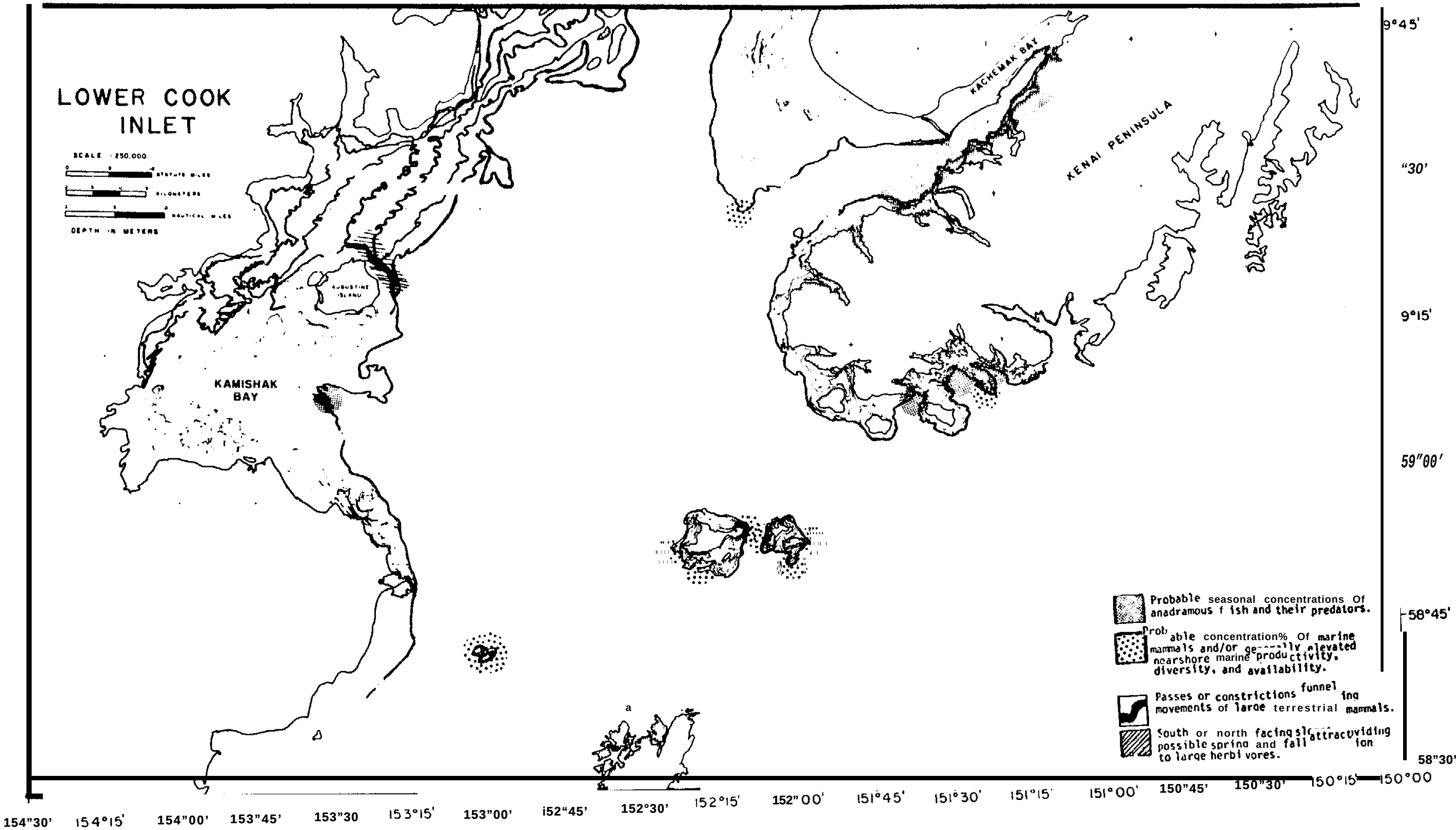


Figure 11-19. Stillstand V with shoreline at -38 m, 9,400 ± 220 B.P. Lower Cook Inlet: Kamishak Bay through Kennedy Entrance to Two Arm Bay.

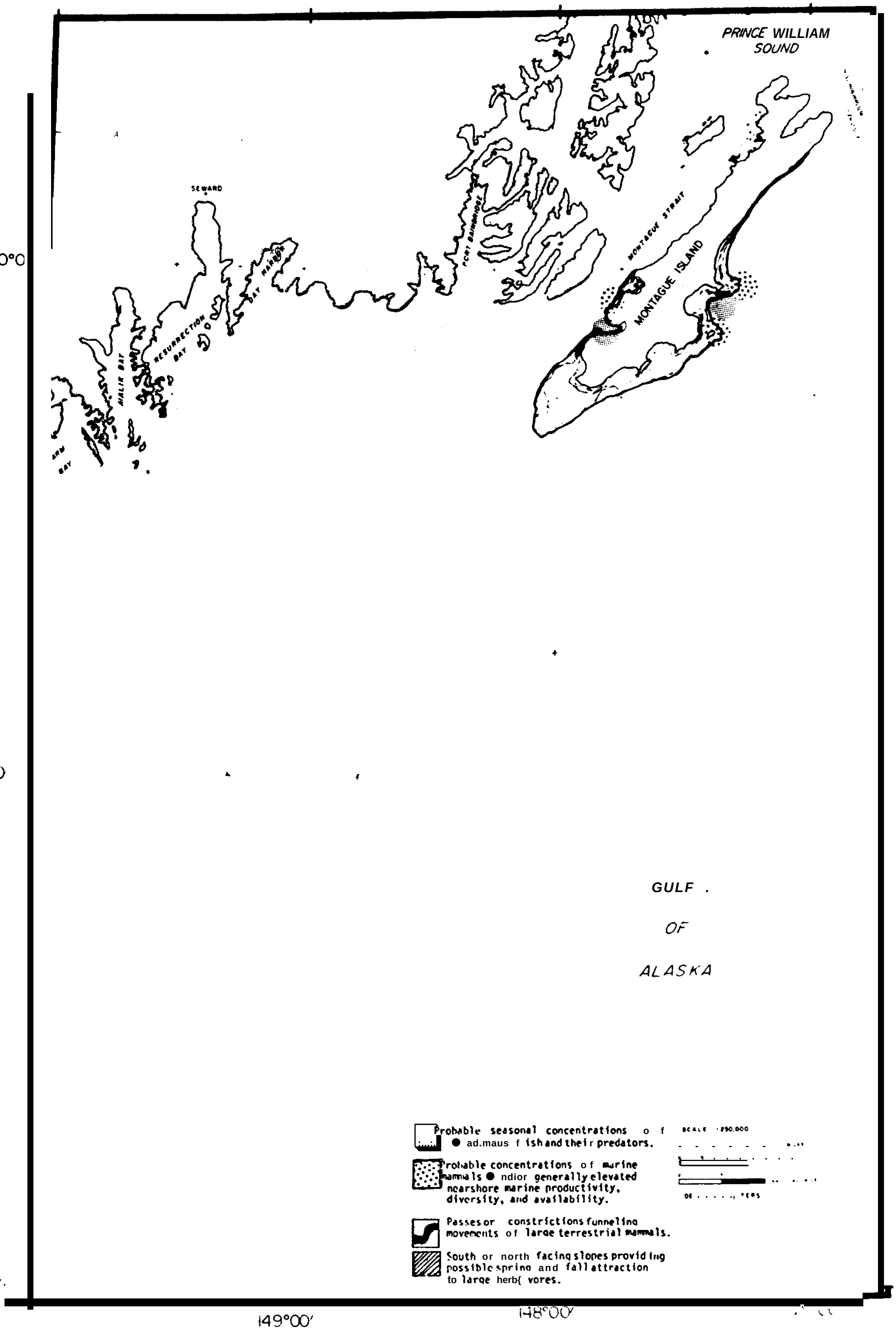


Figure II-20. Stillstand V with shoreline at -38 m, 9,400 ± 220 B.P. Two Arm Bay to Montague Island

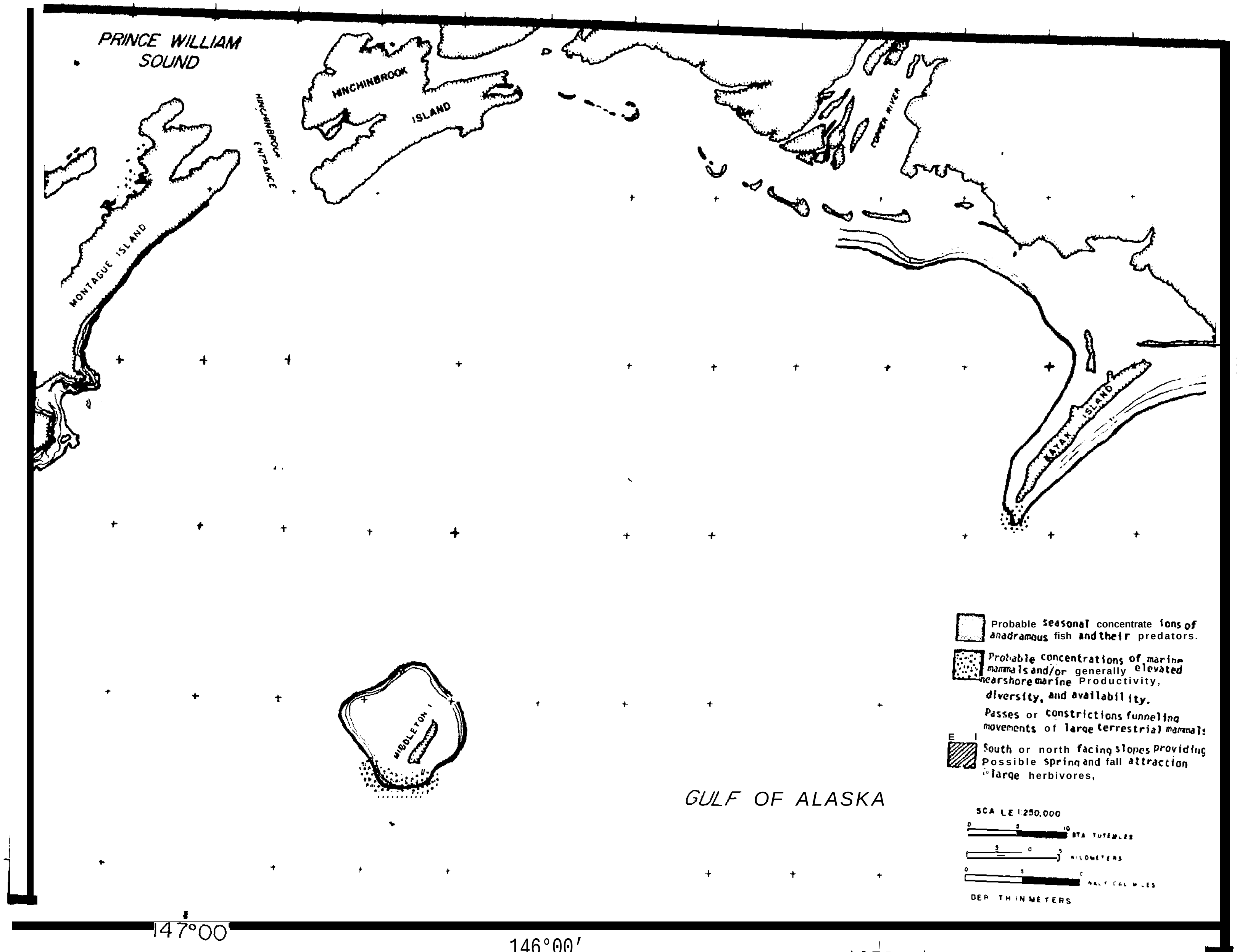


Figure II-21. Stillstand V with shoreline at -38 m 9400 ± 220 BP. Montague Island to Kayak Island and Cape Suckling.

Stillstand VI: 8,700 B.P.

This stillstand must have fallen well within the final Late Wisconsin/Early Holocene climatic warm interval (Table II-2). The climate at this time was probably warmer and at least as wet as at present, with extensive spruce/hemlock/birch forests.

By this time, at -28 m below present level, the sea would have flooded almost all of the shelf, leaving, in most places, only a narrow band emergent along the present coast (Figures II-22 to II-25).

Terrestrial resources were probably about as described for the previous period, though available range would be even more restricted by the rising sea. It seems likely that only in the Cook Inlet region might large mammal resources (moose and caribou) have been sufficient to sustain a subsistence economy, and even here the case is speculative.

In the marine realm the situation may have been much better. Marine resources may, in fact, have been more diverse and abundant than is presently the case, though the factors of salinity and turbidity as a result of accelerated glacial wastage, as discussed earlier, might have compromised the beneficial effects of climatic amelioration. If these turbidity/salinity effects were not too extreme, populations of present species of marine mammals, marine birds, marine and anadromous fish, and intertidal invertebrates might have been expanded and augmented by others such as the northern elephant seal and Steller sea cow.

Areas of probable marine resource potential during this stillstand would have been roughly the same as for the previous one: Kachemak Bay, the southeast coast of the Kenai Peninsula, the Barren Islands, and bays along the western side of Cook Inlet (Figures II-22 to II-24).

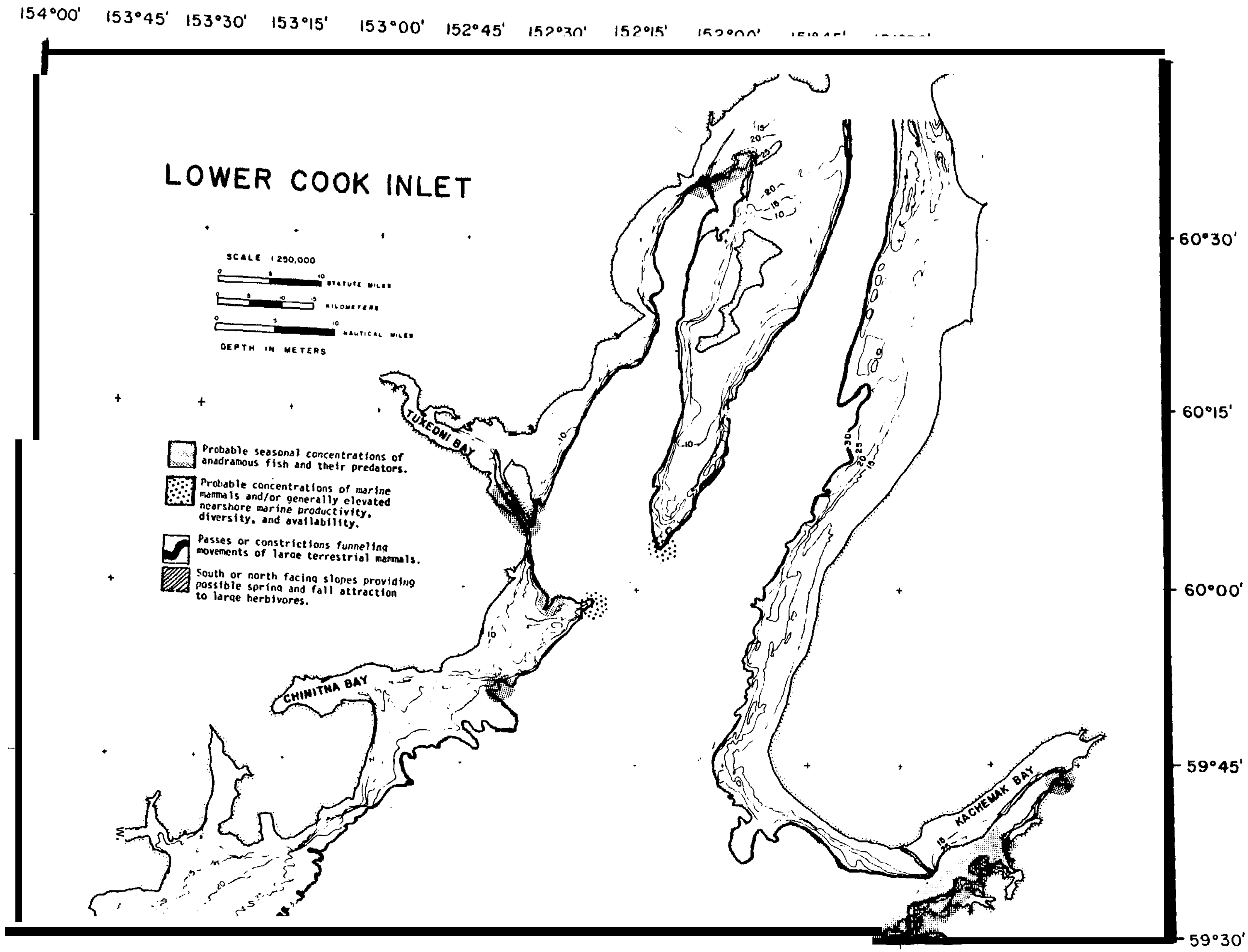


Figure II-22. Stillstand VI with shoreline at -28 m, 8,700 B.P. Lower Cook Inlet: Kalgin Island to Kachemak Bay.

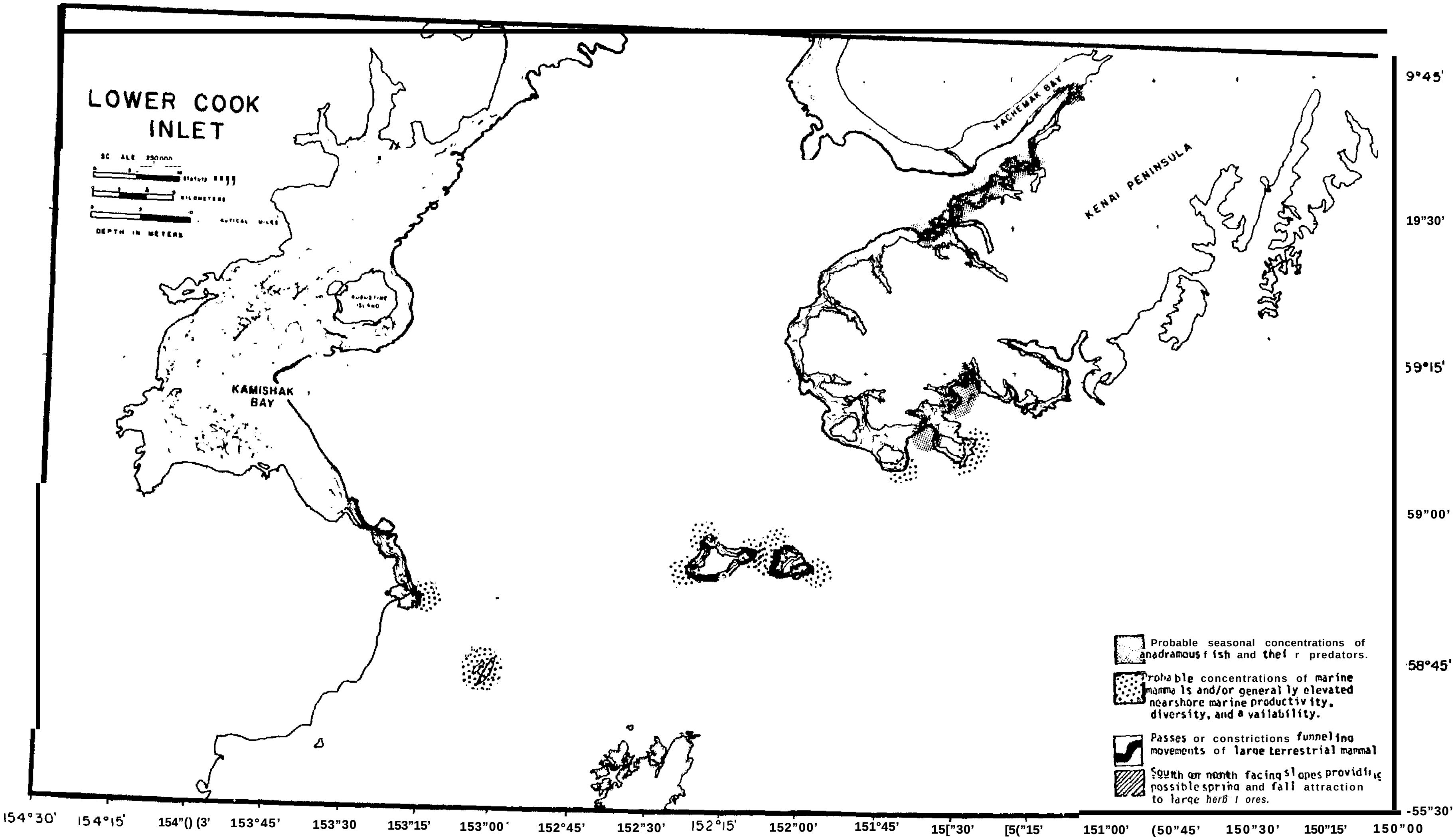


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Figure II-23. Still stand VI with shoreline at -28 m, 8,700 B.P. Lower Cook Inlet: Kamishak Bay through Kennedy Entrance to Two Arm Bay.

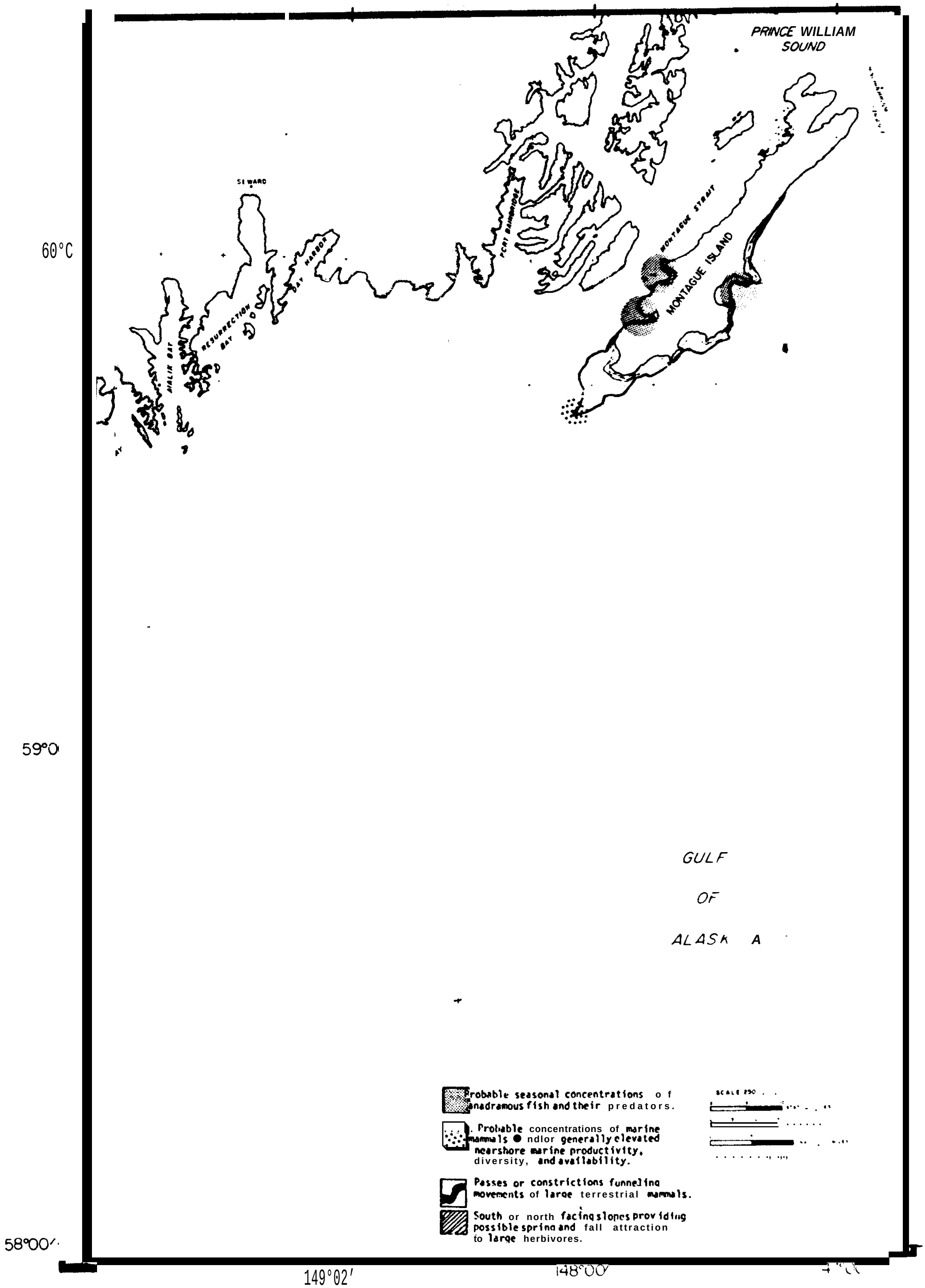


Figure II-24. Stillstand VI with shoreline at -28 m, 8,700 B.P.
Two Arm Bay to Montague Island.

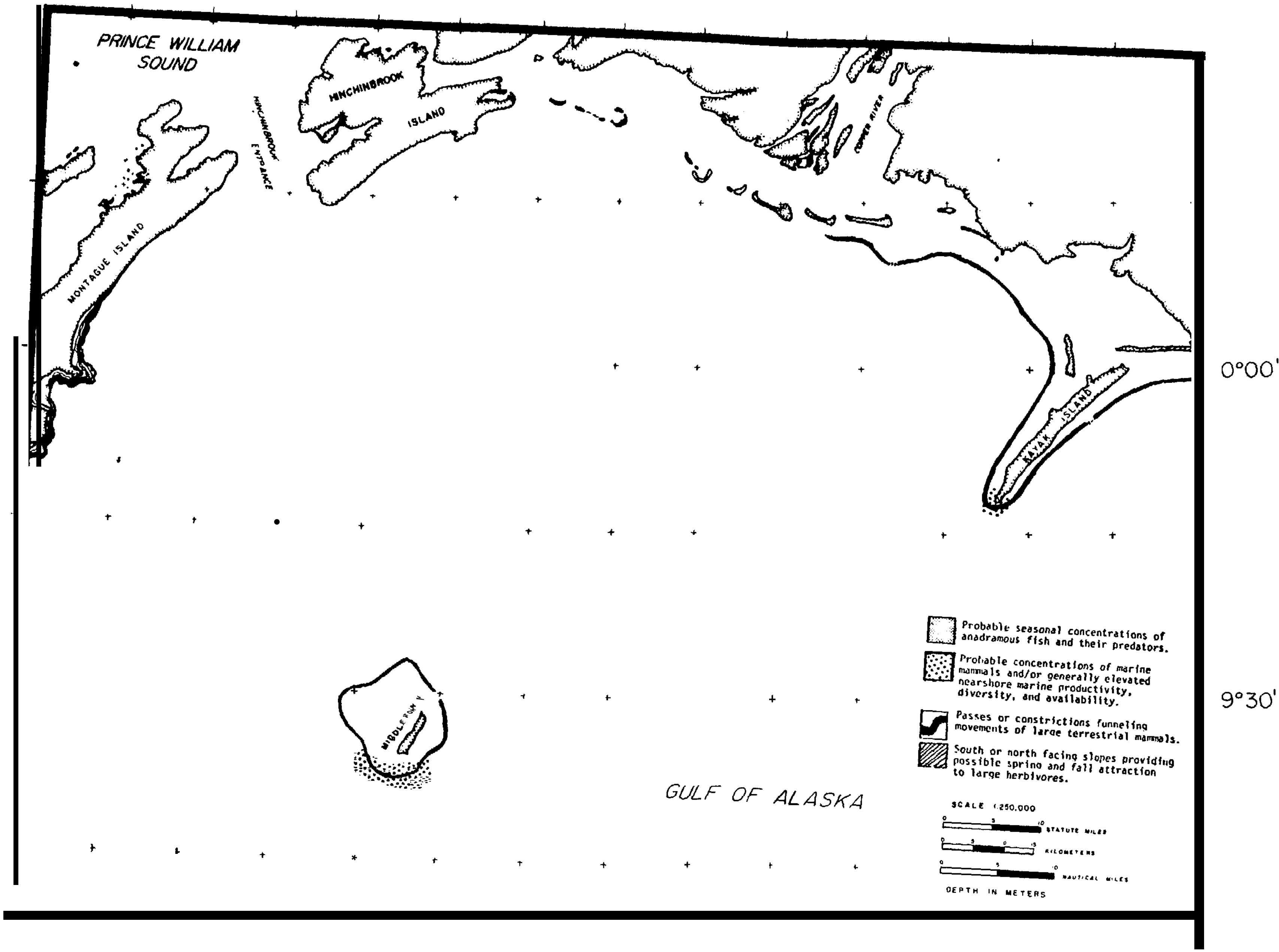


Figure II-25. Stillstand VI with shoreline at -28 m, 8,700 B.P. Montague Island to Kayak Island and Cape Suckling

Synopsis

Over the time interval considered, two distinct areas are apparent, in terms of resource availability, within this study region. The first area--all of emergent Cook Inlet--might have provided a viable terrestrial economy during most or all of the time span, or at least would have provided substantial terrestrial alternatives to a marine-based economy. Over the remainder of the region, including during the latter stillstands the Kenai Peninsula coast south of Kachemak Bay, any subsistence economy must have been primarily marine oriented.

Terrestrial resources in the Cook Inlet area would have included, in addition to small game and freshwater fish, moose, caribou, and perhaps bison. Locales promoting faunal concentrations attractive to subsistence hunters might have been, during the earlier stages of the sequence, the passes and constrictions of central Cook Inlet and the Barren Islands vicinity. During the later stages, as sea level rose to isolate the Barren Islands and flood central Cook Inlet, localities of probable concentration become much more difficult to predict.

Within the Cook Inlet area, marine resources, particularly anadromous fish, might also have been relatively abundant throughout the sequence. During the earlier stillstands, the locales of highest potential would appear to be probable river mouths on the central coast of lower Cook Inlet. As sea level rose, more favorable conditions may have prevailed within Kachemak Bay and the bays of the western side of Cook Inlet.

Viewing the area east of the Kenai Peninsula and Kennedy Entrance, marine resources might have offered slightly greater diversity than within Cook Inlet itself. Such resources probably included anadromous fish, marine mammals, marine birds, marine fish, and inter-tidal invertebrates. All of these resources do occur within Cook Inlet also, but in lesser diversity and abundance than observed along the outer coast and within Prince William Sound. Unfortunately, locales of likely attraction to early subsistence hunters within this area are very difficult to project. Virtually any or all of the bays, river mouths, and headlands might have offered sufficient potential, depending on local conditions.

In considering resource potential and distributions over both of these areas, two major difficulties are encountered. The first is the complex and confusing bathymetry of the region, which may not be truly reflective of past, emergent topography. The second major difficulty is the controversy relating to the extent and effects of Late Wisconsin glaciation over this region. If glaciation was as extensive as some authors seem to feel, the resource potential of the entire region would have been much less than as here described. Also, as glacial wastage ensued and accelerated, the effects of lowered surface salinity and increased turbidity might have depressed nearshore marine productivity to a considerable extent.

III. CHINITNA BAY CULTURAL RESOURCE STUDY: THE GEOLOGY AND ARCHEOLOGY OF THE SOUTHERN SHORE OF CHINITNA BAY, ALASKA

Robert M. Thorson, David C. Plaskett, E. James Dixon, Jr.

INTRODUCTION

This chapter presents the results of geological and archeological investigations carried out during June of 1978 at Chinitna Bay, Alaska. The fieldwork was performed in an attempt to relocate and test an early archeological site reported by Frank C. Hibben (1943). The reported "Early Man" site was not found during the interval of archeological testing, but the site area was relocated and geologic data collected has significant bearing on the possible existence and age of the site described by Hibben.

Chinitna Bay forms a prominent 20 km long, 5 km wide east-west trending marine inlet on the west side of Cook Inlet (Figure III-l). The bay is located approximately 200 km southwest of Anchorage, and is situated between the massive Iliamna and Augustine volcanoes to the north and south, respectively. In Chinitna Bay, the circulation of marine water is dominantly counterclockwise with a mean tidal range of 4 m. Waves which strike the south side of the bay generally originate from the northeast. Several major glacial valleys which descend from the flanks of Mt. Iliamna enter the north side of the bay and are currently discharging large quantities of mud and silt at the head of the bay. These deposits are largely reworked by the tides and currents into large mudflats near the western end of the bay. Isostatic rebounding is reported in the general vicinity of Chinitna Bay (Dettennan and Hartsock 1966), and elevated lagoonal sediments were observed above the present shoreline of the bay. Tectonic movement appears to have affected the shoreline in the past. However, the 1964 Alaska Earthquake caused subsidence of less than 45 cm along the lower Cook Inlet coast (Pflaker et. al. 1969).

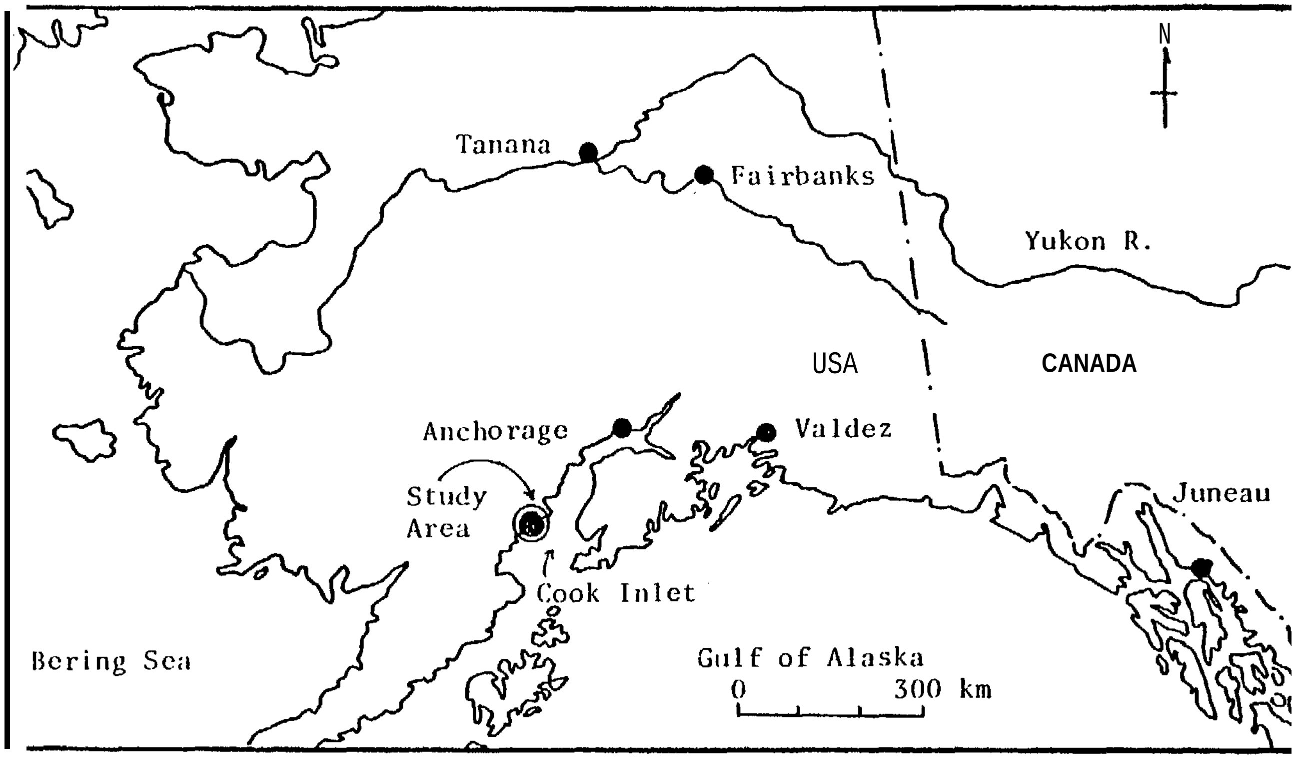


Figure III-1. Map showing the location of the study area.

NARRATIVE OF THE 1978 FIELD INVESTIGATION

The Chinitna Bay archeological field investigations commenced 1 June 1978. The field crew consisted of E. James Dixon, Jr. (Co-Principal Investigator, University of Alaska Museum) , Dr. Samuel Stoker (Co-Principal Investigator, Institute of Marine Science, University of Alaska), Robert M. Thorson (Geologist, University of Washington) , David c. Plaskett (Research Associate in Archeology, University of Alaska Museum), and William Civish (Bureau of Land Management/Outer Continental Shelf Office, observer and Field Assistant). Later, the field party was joined by Douglas Reger (Alaska State Archeologist, and representative of the State Historic Preservation Office).

Prior to the commencement of field work, Federal and State antiquities permits were secured, and permission to proceed was obtained from the appropriate native groups. On 31 May, the day before departure for Chinitna Bay, food, supplies, and field gear were gathered in Anchorage. On this date Robert Thorson arrived from Seattle.

Early on the morning of 1 June the field crew assembled in Anchorage for the flight to Chinitna Bay. Air transportation was provided by the Bureau of Land Management/Outer Continental Shelf Office, through the Department of Interior's Office of Aircraft Semites. The field party flew in a Grumman Goose from Anchorage to Chinitna Bay in two groups. Upon landing at Chinitna Bay a brief reconnaissance was made along the south shore between Sea Otter Point and Sinking Creek to find a suitable campsite. Camp was set up on several elevated beach ridges located along the present shoreline approximately 1.2 km east of Sinking Creek (Figure III-2).

The remainder of 1 June was spent conducting a visual reconnaissance of the south side of Chinitna Bay from Sinking Creek to Coffin Creek. A number of natural erosional exposures revealing the substrata were found along the modem shoreline and on the tidal mud flat southwest of Seal Spit. Several of these exposures are identical to those shown in Hibben's report (1943 Plate XIV) , and it was

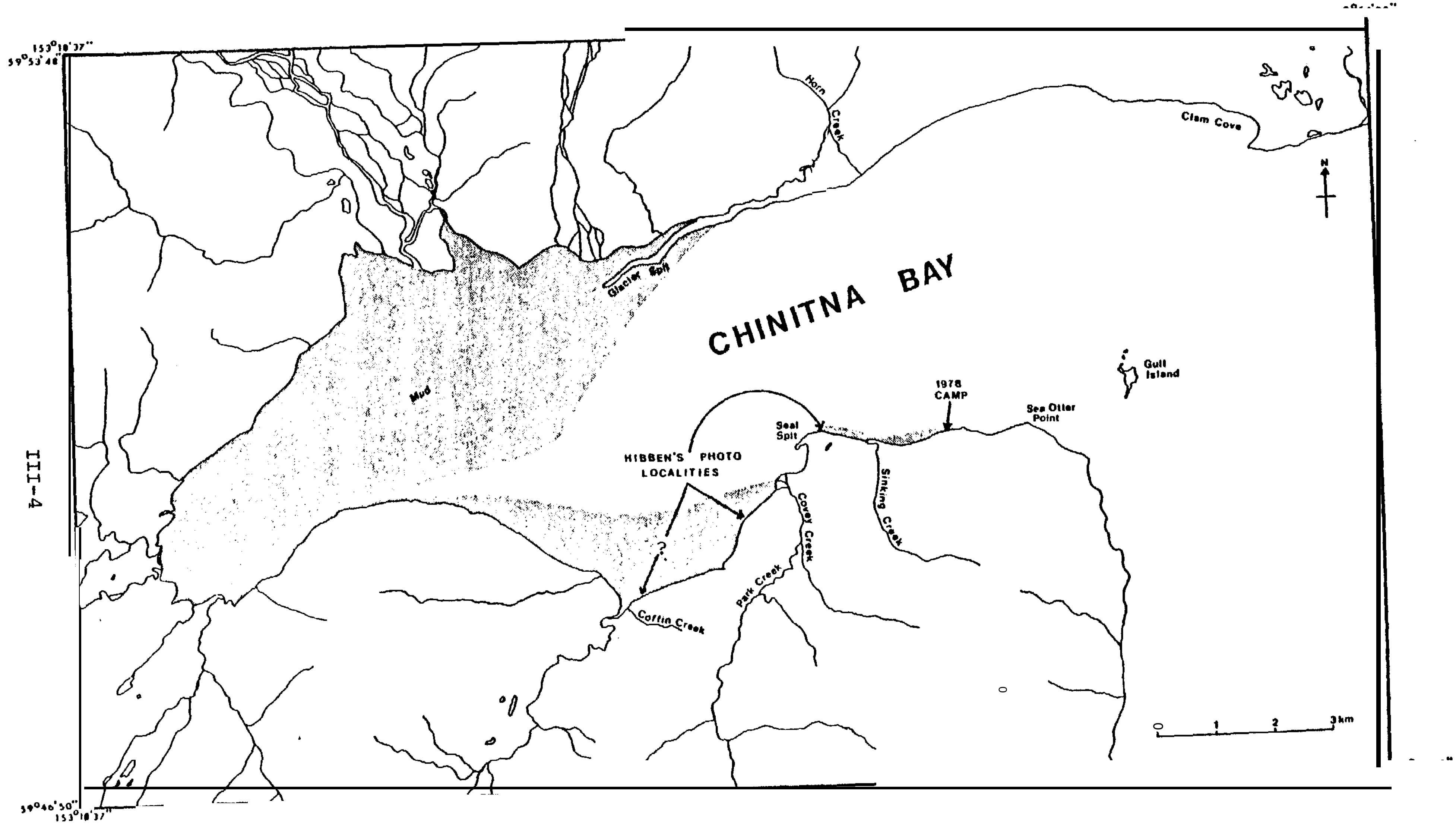


Figure III-2. Map of Chinitna Bay.

actually possible to relocate his photo localities. The exposures examined by Hibben during fieldwork in 1941 were recognizable and it does not appear that they have undergone significant alteration during the intervening 37 years. The stratigraphy observed in the natural exposures generally conformed to Hibben's description. However, no single exposure exhibited the complete stratigraphic sequence which he described. During this preliminary reconnaissance large mammal bones from two beluga whales were observed on the tidal mud flat southwest of Seal Spit.

Based on the reconnaissance of 1 June it was determined that the photo which Hibben (1943 Plate XIVd) reported as the center of the Chinitna Bay archeological site had been taken on the tidal mud flat approximately 0.8 km southwest of the mouth of Covey Creek (Figure III-2). With the center of the archeological site located, as Hibben identified it, there remained the task of determining the north and south limits of the site area which he described. Hibben (1943:257) stated that the site "extends along the western and southwestern side of the bay for roughly a mile and a half." The southeast end of the site, and the greatest concentration of cultural material, was reported to be near the mouth of a small unnamed creek.

In an attempt to relocate the limits of the site area reported by Hibben, our field party divided into three groups on 2 June. Two small creeks, Sinking Creek and Covey Creek, were thought to be the most probable locations for the unnamed creek reported by Hibben at the southeast end of the site area. Plaskett and Baran conducted a reconnaissance in the vicinity of the mouth of Sinking Creek and located an exposure several hundred meters west of the mouth which was identical to one shown in Hibben's (1943) Plate XIVc. This exposure extended along the edge of an elevated salt marsh deposit directly behind the modern beach. A 2 m wide test exposure was excavated vertically and stepped laterally toward the shoreline to a depth of 4.5 m below the upper surface of the elevated marsh deposit. Three strata were observed in this test pit and from top to bottom consisted of the following: (1) below the modern ground surface was a 15 cm dark brown peaty layer, (2) the peaty layer capped a 1.5 m thick layer of heavily oxidized brown clayey silt, and (3) below the brown clayey silt was a blue-gray unoxidized clay which was excavated to a depth of 1.5 m. This stratigraphic section exhibited characteristics which were similar to the stratigraphy described by Hibben.

The stratigraphy exposed west of Sinking Creek on 2 June may correlate with Hibben's stratigraphic units as follows: the lowest unit identified, the unoxidized blue-gray clay, may be the same as Hibben's lower blue clay layer. The 1.5 m thick oxidized brown clayey silt which was observed directly above the blue-gray clay could be the layer which Hibben called a “muck of loess-like consistency,” which was reported to be 4 feet thick at the south end of the site area near the unnamed creek. The dark-colored humus stratum which Hibben identified as the cultural stratum was not found between the blue-gray clay and the oxidized brown clayey silt on 2 June. No volcanic ash was observed in the oxidized brown clayey silt layer. The 15 cm thick dark brown peaty layer observed directly below the modern ground layer correlates with Hibben's peat layer.

Dixon and Civish conducted an intensive reconnaissance on 2 June around the mouth of Covey Creek and three small streams to the northeast between Covey Creek and Seal Spit. Thorson and Stoker conducted a reconnaissance along several large exposed bluff faces on the shoreline east of Coffin Creek. No prehistoric cultural evidence was located by any of the three survey groups on 2 June.

On 3 June Plaskett and Thorson returned to Sinking Creek and dug several test pits between Sinking Creek and the test trench of 2 June. The first test was a 1 m wide cut into an exposure on the north bank of Sinking Creek and located approximately 25 m up the creek from the shoreline. The strata exposed in this test pit consisted of bedded fluvial gravels which had been deposited by Sinking Creek. A second test pit was excavated along the eroding edge of the elevated salt marsh deposit at a location approximately

75 m west of the mouth of Sinking Creek. This test pit was 1 m wide and was excavated to a depth of 1.5 m. Strata consisted of interbedded layers of beach gravels and silt layers. A third test pit was excavated along the same edge of the elevated salt marsh deposit approximately 30 m east of the test trench excavated on 2 June. The stratigraphy in this test pit revealed the same basic stratigraphic units found in the test trench of 2 June with one exception, a 2 cm thick organic layer separated the lower blue-gray clay from the higher oxidized brown clayey silt. This organic layer may represent the humus layer which Hibben identified as the cultural stratum. We carefully troweled and screened a 1 x 2 m area of this layer but found no cultural evidence. Interestingly, tree stumps, some of which are upright and sitting at approximately the same level as the 2 cm thick organic layer, can be observed in this area. However these tree stumps have apparently dropped to their present position as a result of natural erosional undercutting below their bases along the edge of the elevated salt marsh deposit.

Dixon and Baran began subsurface testing in the vicinity of Covey Creek on 3 June. Excavation was begun on a 1 x 10 m test trench located directly northeast of Covey Creek at the mouth of a small stream. The trench extended from the modem beach gravels past the high water mark into the vegetated shore. The ubiquitous blue clay was located at the erosional face of the high water line approximately 50 cm below the surface. Stoker and Civish conducted a boat reconnaissance along the south shore of Chinitna Bay. Again on 3 June, no prehistoric cultural evidence was located by any of the field crew.

Excavation was continued by Dixon and Civish on 4 June at the test trench northeast of Covey Creek. The trench was oriented perpendicular to the modem shoreline and was excavated to a depth of 1 m. Horizontally along the test trench, the 6 m nearest the shoreline revealed recent beach gravels which were overlying oxidized beach gravels interbedded with sand and silt. The 4 m further from the shoreline revealed oxidized brown clayey silt overlying blue-gray clay. No cultural evidence was found in the test trench.

A large landslide exposure, located along the shoreline approximately 0.8 km west of Sea Otter Point was investigated by Thorson and Stoker on 4 June. This exposure had upright tree stumps in place directly under a colluvial deposit which varied in thickness from 5 to 20 m. Testing was begun just above the contact between upper colluvium and the lower blue-gray clay. No cultural evidence was located.

Plaskett and Baran excavated a 1 m wide test pit into an eroding bluff edge along the modern shoreline approximately 0.8 km east of the mouth of Sinking Creek. This test was excavated vertically to a depth of 2 m and revealed interbedded layers of beach gravels, sand, and silt. After completing this test excavation, Plaskett and Baran joined Thorson and Stoker at the exposure west of Sea Otter Point. No prehistoric cultural evidence was located by any of the field crews on 4 June. Douglas Reger arrived at Chinitna Bay by aircraft on the evening of 4 June.

On 5 June Plaskett and Baran returned to Sinking Creek. Two test pits were excavated approximately 10 m west of the mouth. Both test pits were located at the edge of a low exposure directly behind the modem beach, and were excavated to a depth of 1.5 m. Both test pits revealed interbedded beach gravels, sand, and silt. Thorson and Reger returned to Hibben's photo locality on the tidal mud flat southwest of Seal Spit (1943 Plate XIVd) to collect geological samples and then proceeded to the exposures east of Coffin Creek to describe the strata and collect geological samples. Again on 5 June no prehistoric cultural evidence was located by the field crews.

Stoker, Plaskett, Thorson, and Baran conducted a reconnaissance of Gull Island at the mouth of Chinitna Bay on 6 June. It was hoped that a reconnaissance of the island would provide information on isostacy in the bay, since the island appeared to be an uplifted wave abraded platform. A search was also made for Quaternary age surficial deposits and archeological evidence. A visual reconnaissance was made on the island, and natural exposures were examined. Numerous small depressions measuring 1 m or less in diameter were found on the island, but appeared to have been formed by nesting sea gulls. Thorson examined the subsurface stratigraphy and found 1.3 m of deposition above bedrock. No cultural evidence was located on Gull Island. Dixon, Civish, and Reger returned to the large landslide exposure west of Sea Otter Point on 6 June and continued testing at the contact between the colluvium and the blue-gray clay layer. No cultural evidence was discovered during this testing.

On the morning of 7 June Thorson described the geologic strata in the test pit 0.8 km east of Sinking Creek which was excavated by Plaskett and Baran on 4 June. Later in the day Thorson and Plaskett conducted a geological reconnaissance on the south slope of Horn Mountain, on the north shore of Chinitna Bay, in an attempt to locate glacial trimlines useful for inferring the late Pleistocene glacial limits in Chinitna Bay. Stoker conducted a boat reconnaissance of the north shoreline between Glacier Spit and Horn Creek. Dixon, Civish, Baran, and Reger backfilled the test pits in the vicinity of Covey Creek and Sinking Creek. No prehistoric cultural material was located by the field crews on 7 June.

On 8 June Thorson returned to the large landslide exposure west of Sea Otter Point and described the geologic strata. The rest of the field crew dismantled the field camp in preparation for leaving. On the afternoon of 8 June the field party departed Chinitna Bay for Anchorage in two groups by floatplane.

GEOLOGY OF THE SOUTHERN SHORE OF CHINITNA BAY

1. Bedrock

The bedrock along the south side of Chinitna Bay consists largely of Jurassic age sediments (Detterman and Hartsock 1966). Near the west part of the study area they are dominantly eugeosynclynal in origin (Tuxedni Group) consisting of poorly sorted, reworked volcanic sediments (graywacke). The youngest Jurassic rocks along the south shore of Chinitna Bay belong to the Naknek Formation and consist largely of arkosic sediments. They were derived largely from an extensive quartz diorite pluton which lies northwest of Chinitna Bay. Lava flows of Neocene age, which erupted from Iliamna volcano, are restricted to the northern side of the bay.

The Jurassic sediments along the south side of Chinitna Bay dip easterly as part of a large northeast trending anticline. The dominant regional structural feature is the Bruin Bay Fault, where folded sedimentary rocks to the east are being thrust under the Aleutian Range. Continued activity of the Aleutian volcanoes and recent faulting in the Cook Inlet area suggest that vigorous underthrusting is still occurring.

2. Glacial Geology

During Quaternary time, Chinitna Bay was repeatedly glaciated by large east-flowing ice streams which originated in the Aleutian Range (Karlstrom 1964). The most recent major glaciation was named the Naptowne Glaciation by Karlstrom. Although Karlstrom inferred that the entire Aleutian Range was covered by ice, Naptowne-age glacial erosion features appear to extend no higher than about 600 m. These features are best preserved at about 610 m above present sea level on both the north side of Mt. Chinitna and the east edge of Horn Mountain (on the north side of the bay). They indicate that Chinitna

Bay was largely filled by confluent valley glaciers but that the major mountains projected well above the ice limit. Radiocarbon dating of the Bootlegger Cove Clay near Anchorage (Schmoll et al. 1972) indicate that Naptowne glaciers were undergoing rapid retreat by 13,000 to 14,000 years ago.

The amount of isostatic adjustment of the Chinitna Bay region to glacial unloading is unknown, but it probably played a significant role in the subsequent Holocene sea level history. Pronounced neoglacial moraines on the flanks of Iliamna Volcano indicate that climates fluctuated widely during late Holocene times.

3. Modern Coastline Processes

The relatively large tidal range and the high frequency of winter storms in Chinitna Bay and the large amount of sediment supplied to it make the intertidal and supratidal environments very dynamic. Three generalized profiles taken normal to the present coastline (Figure III-3) illustrate both the types of processes which are occurring and the sediments which are currently being deposited. The location of the three profiles depicted in Figure III-3 are shown in Figure III-4.

The origin of the extensive salt marshes which occur in the study area is well illustrated by Profile S3 on Figure III-3 and Appendix III-A. The modern beach bar appears to be formed only during storms associated with very high tides. During these episodes, suspended gray mud is deposited all over the grassy surface of the salt marsh and driftwood is rafted in at isolated localities. Pods and clumps of stony gray mud to about 20 cm diameter are occasionally present on the salt marsh. They are interpreted to have been deposited by floating driftwood or icebergs. Organic material consisting of distinct layers of grassy peat with occasional wood fragments commonly occurs near the top of the muddy sediments. With depth, the organics appear to become more finely divided and the gray mud appears to have

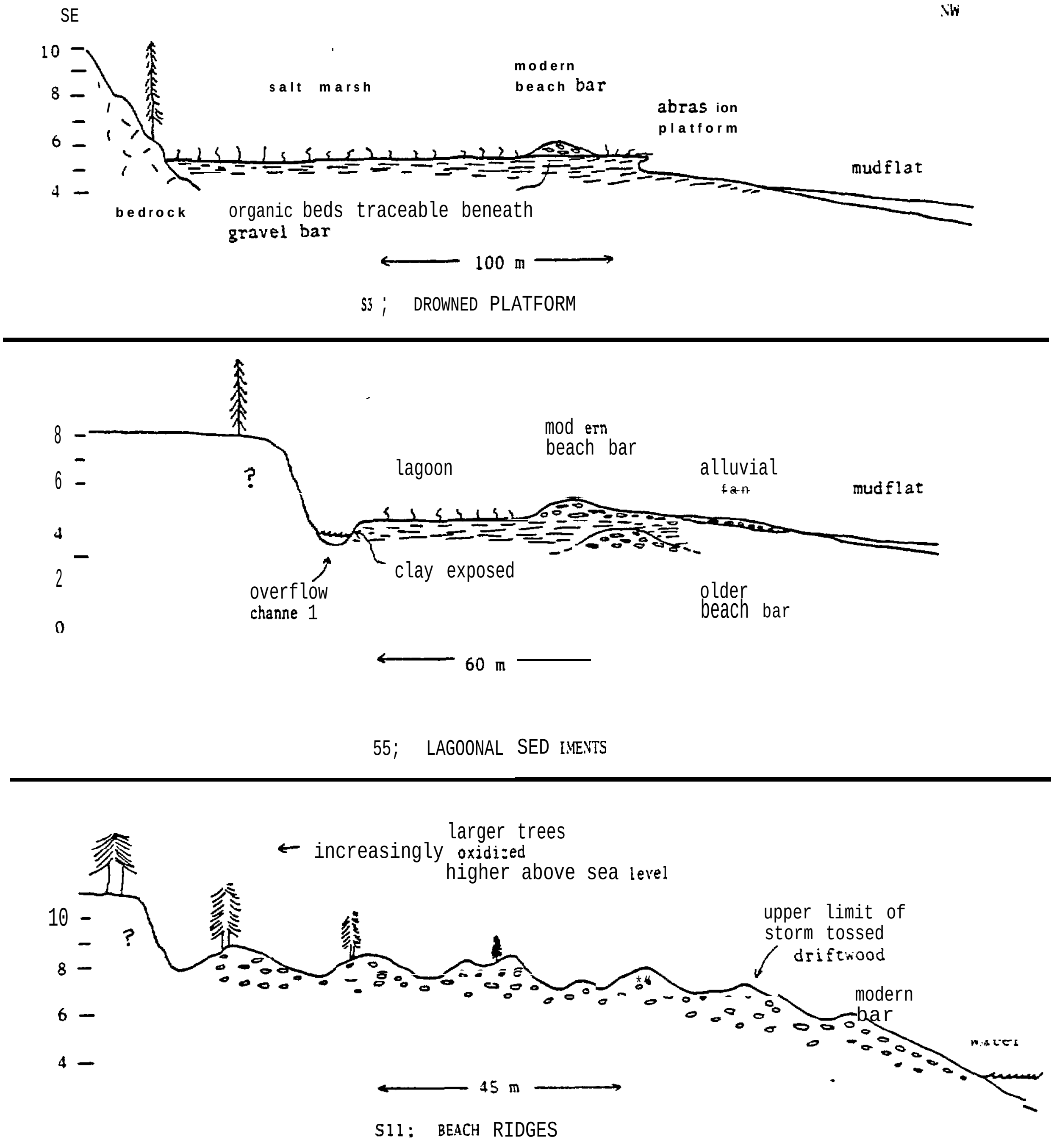


Figure III-3. Generalized geologic cross sections perpendicular to the shoreline at three localities along the southern shore of Chinitna Bay (note: vertical scale in meters above sea level).

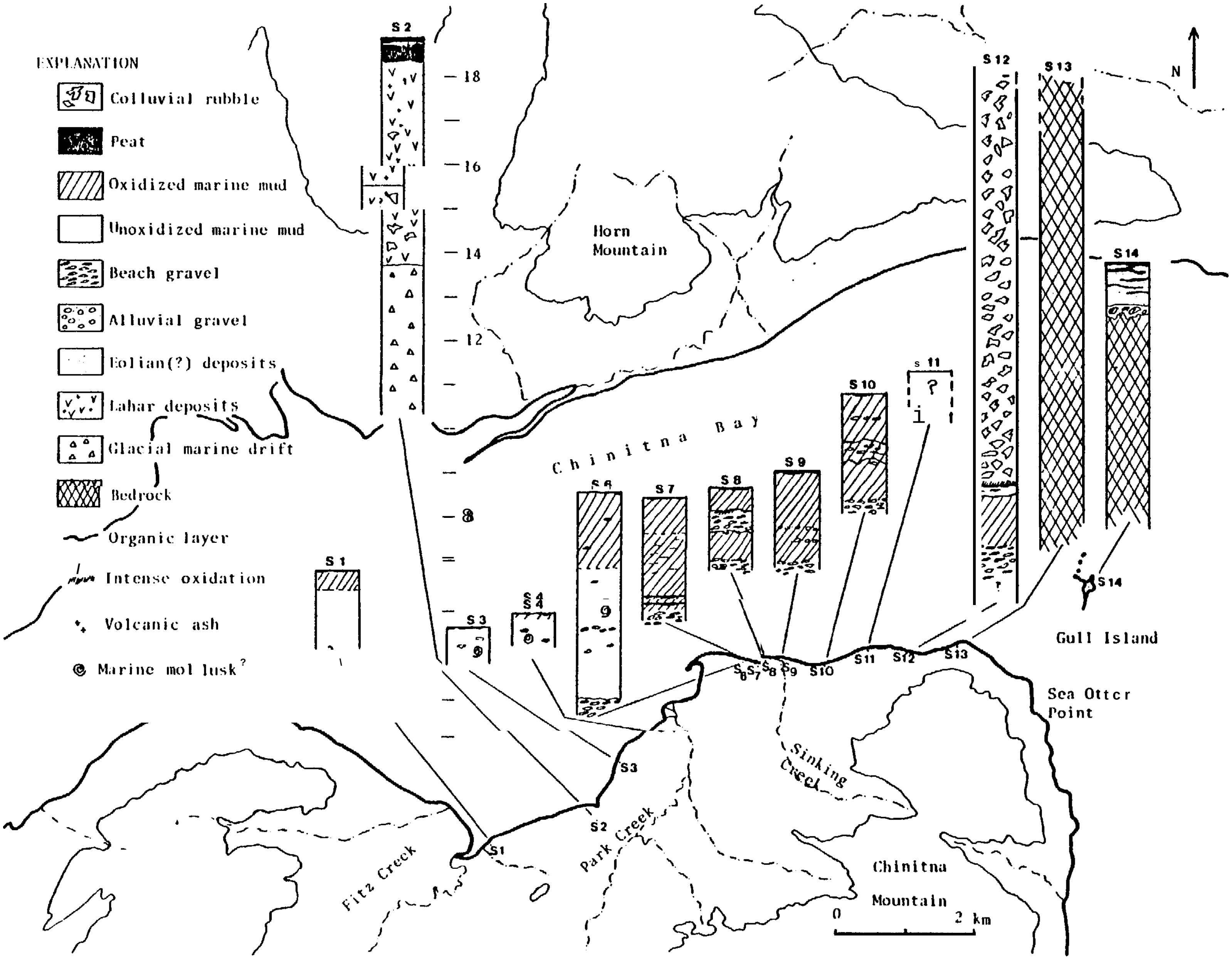


Figure III-4. Locations and generalized profiles of stratigraphic sections exposed along the southern shore of Chinitna Bay (note: vertical scale in meters above sea level) .

a blue-gray color. Erosion rather than deposition is occurring seaward of the modern beach bar. The slightly older marine muds below those currently being deposited are compact enough to form a clearly recognized undercut slope and abrasion platform.

Profile S5 "(Appendix III-A and Figure III-3) illustrates the deposition of nearly identical but slightly stony marine mud in a much more localized lagoonal environment. The modern beach bar is seaward of a small, fully vegetated mud flat which lies seaward of a tidal channel. Older beach gravels occur below the modern bar and are interfingered with marine muds. Alluvial sediments are also present but consist largely of reworked beach gravel.

Profile S11 (Appendix III-A and Figure III-3) illustrates the progressive decrease in age of a series of beach bars formed during offlap. With increasing age, the bars become more vegetated and oxidized, and have shallower slopes. A blanket of gravel is currently being deposited across a wide area below the bar crests.

4. Stratigraphic Sections

a. Description and Interpretation

Fourteen measured stratigraphic sections along the south side of Chinitna Bay between Coffin Creek and Gull Island are described in Appendix III-A. The locations and interpretations of these measured sections are shown in Figure III-4. The base level control for these sections was the high afternoon tide of 5 June 1978 which was 524 cm above mean sea level.

Sections S1 through S6 consist largely of clayey silt and silty clay with common dispersed gravel clasts and wood fragments. Rare marine pelecypods and gastropod were found in the sediments where they were gray and unoxidized. Oxidation was common near the top of the sections. Subangular gravel was found near the base of Section S6 and is presumed to underlie Sections S1 through S4 as well.

These sediments clearly originated as salt marsh deposits which form a blanket over older beach gravel. Oxidation appears most pronounced in the higher sections. Radiocarbon dates of 375 ± 120 years B.P. from wood near the top of Section S3 and 600 ± 100 years B.P. on organic soil from the top of 'Section S2 indicate a relatively recent age for these sediments (Table III-1 and Appendix III-A).

Sections S7 through S10 exhibit fully oxidized clayey silt and silty clay with occasional thin layers of subangular gravel. Peat layers and paleosols were occasionally present in these sediments. Subrounded arkosic gravel which is interpreted as alluvial in origin, was present in Section S9. Collectively these sediments are interpreted to be largely marine muds and salt marsh deposits which overlie beach grave 1. The included gravels appear to have been deposited as beach grave 1. The included woody peats and paleosols suggest that an interval or intervals of subareal exposure interrupted the generally submergent conditions. A radiocarbon date of 300 ± 130 years B.P. has been determined from wood near the bottom of Section S7 (Table III-1 and Appendix III-A).

Section S12 consists of at least 10 m of angular, blocky monolithologic rubble in a very poorly sorted mud matrix. These sediments occur as part of a large earthflow complex which now appears to be largely stable. The colluvial sediments lie unconformably on a unit of gray clayey silt which has a bluish appearance, and includes two prominent woody peat layers. A radiocarbon date of 285 ± 100 years B.P. has been determined from the top of this peat (Table III-1 and Appendix III-A). A very vivid oxide-stained zone occurs at the contact between the colluvium and the clayey silt. Below the peat-bearing clayey silt is oxidized massive clayey silt which conformably overlies subangular grave 1. The peats are interpreted as terrestrial organic layers which bracket and overlie salt marsh deposits. The lowest unit is interpreted to be beach gravel.

Section S14 from Gull Island exhibits sediments which are radically different from the mainland stratigraphic sections. In the

Date (yr B.P.)	Laboratory Number	Sample Number	Material Dated	Stratigraphic Position		Stratigraphic Significance
				Section	Unit	
600 ± 100	Gx-5654	UA78-73-1	peaty silt	S2	2	Maximum age for past cap at Park Creek, the western end of the Chinitna Bay “archeologic site.”
375 ± 120	GX-5655	UA78-73-2	wood	S3	2	Maximum age of “blue clay" at the central portions of the Chinitna Bay “archeologic site.”
300 ± 130	GX-5656	UA78-73-3	compressed log	S7	3	Maximum age of “blue clay” at Sinking Creek, the suggested most intensively occupied area of Chinitna Bay “archeologic site.”
4,190 ± 155	GX-5657	UA-78-73-4	organic silt	S14	2	Minimum age for creation of the marine abrasion platform at 8.2 m above present sea level. Dates episode of "eolian(???) activity” on Gull Island.
285 ± 100	GX-5657	UA78-73-5	compressed wood fragments	S12	2	Maximum age for landsliding and for the suggested occupation of Chinitna Bay “archeologic site.”

Figure III-5. Radiocarbon samples collected from the south shore of Chinitna Bay.

field the silty fine sands appear very similar to loess; a laboratory size analysis supports this interpretation (Appendix III-B). The well-sorted sand layers also appear to be largely eolian in origin. They overlie weathered bedrock rubble. A radiocarbon date of 4,190 ± 155 years B.P. has been determined on soil organics from the middle of the silty fine sand unit (Table III-1 and Appendix III-A) . The upper surface of Gull Island for its complete length (0.5 km) forms a prominent terrace which lies about 12.5 m above present sea level. This terrace was interpreted by Detterman and Hartsock (1966) as a marine abrasion platform which was cut into bedrock by wave action. Fieldwork during this study supports this interpretation.

Section S2 near Park Creek is also radically different from Sections S3 through S10. S2 is capped by a thick section of peat and peaty silt which includes a well-defined layer of white volcanic ash . The peat overlies brown clay and clayey sand which contain abundant lapilli fragments and less commonly angular monolithologic rubble. This unit is interpreted to be a weathered lahar (volcanic mudflow) . It probably resulted from mudflow activity which mixed tephra and local rock rubble. The volcanic constituents appear to have been largely weathered to a very plastic clay. The underlying unit between 1,350 and 1,550 cm above sea level is very poorly exposed but is interpreted to be largely colluvial in origin.

Gray silt below the colluvial sediments contains abundant rounded quartz granules and pebbles, reflecting a provenance outside the south Chinitna Bay area. They may have been derived from the large quartz-diorite pluton which lies northwest of Chinitna Bay and were probably carried to Section S2 by glacier ice. The gray silt appears to be ponded water sediment and is therefore interpreted as glacial marine in origin because no lacustrine ice dam appears reasonable topographically. It probably was deposited at a time when the site lay below present sea level and when glaciers were calving into Chinitna Bay.

b. Evidence for Crustal Tilting

The presence of the Gull Island uplifted marine abrasion platform at 12.5 m asl and of oxidized salt marsh sediments which lie well above the modern limit of storms (10.8 m asl) indicate that a marine regression has occurred at some time since the Naptowne glaciation. The top of Sections S3 through S11 appear to represent the same geomorphic surface, and show an easterly increase in altitude from 5.6 m to 11.3 m above present sea level (Figure III-5). The Gull Island abrasion platform appears to lie on the same trend as the deformation suggested by the raised marine sediments. The pattern of deformation does not appear to have been regular as no straight line can be drawn through the points. If a drop in eustatic sea level were responsible for the marine regression, the tops of all stratigraphic sections should be raised relative to sea level by the same amount. Clearly this is not the case. Regional isostatic recovery in response to glacial unloading during Naptowne deglaciation could possibly have been responsible for the regression, but it also should have caused nearly equal uplift at all stratigraphic sections. Isostatic uplift should also have been rapid, yet the salt marsh sediments clearly reflect nearly stable sea level for the period of their deposition (within a small amplitude of sea level fluctuation). The regression and apparent tilting of the sections are therefore interpreted to be due to tectonic causes. Sections S4 through S14 appear to have been uplifted during westward tilting; Section S3 appears to be undergoing drowning. Section 1, 3 km to the west of Section 3, also appears uplifted, but its relation to the other sections is uncertain.

Major changes in the wind or current circulation patterns in Chinitna Bay have probably not occurred in the past several hundred years. Thus, the progressive offlap of beach ridges at Section S11 may be due to tectonic causes as well.

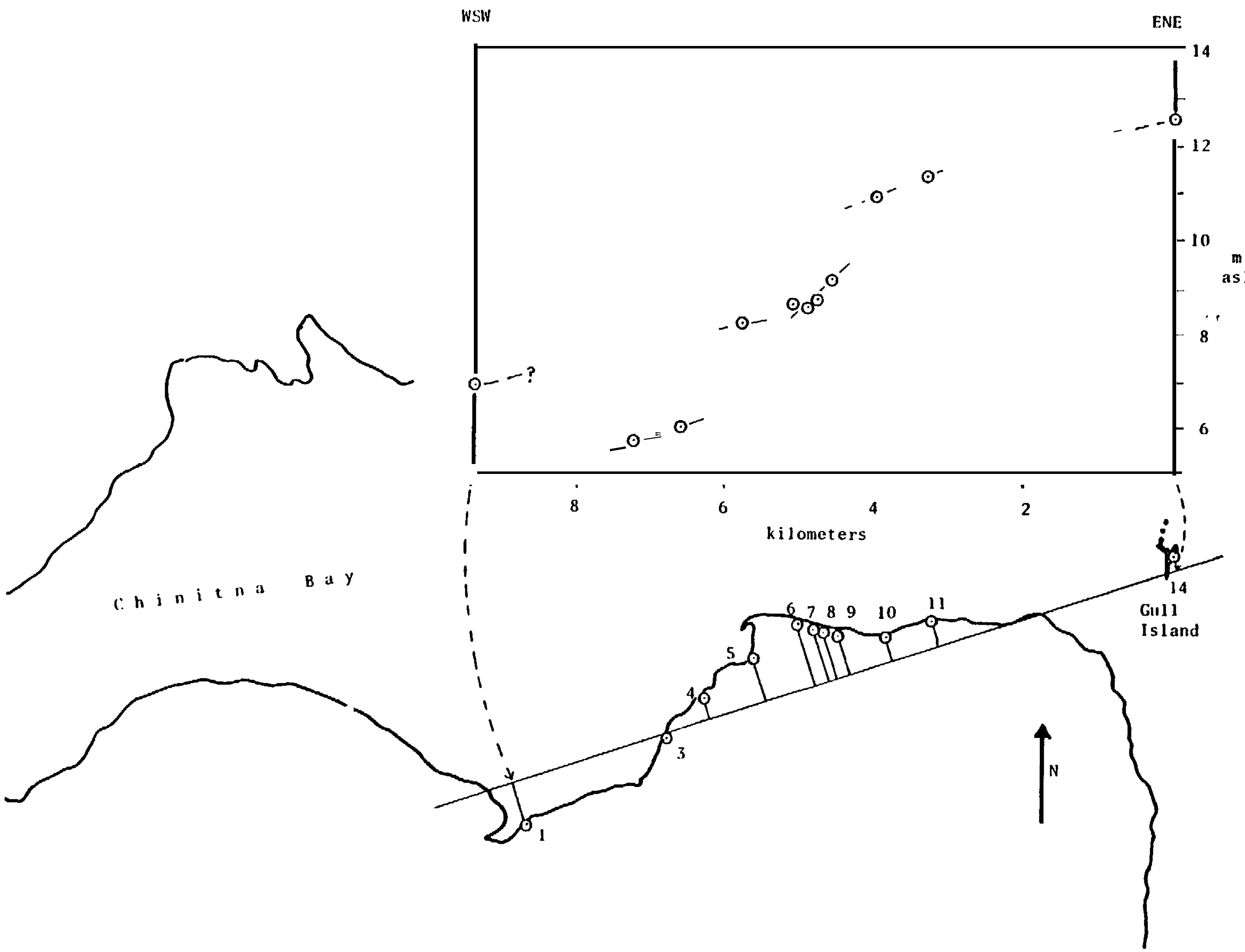


Figure III-6. Graph of topographic profiles showing the tops of stratigraphic sections along the southern shore of Chinitna Bay (note: vertical scale in meters above present sea level; horizontal scale in kilometers west of section S14 on Gull Island).

5. Inferred Geologic History

Near its mouth, Chinitna Bay appears to have been filled to about 600 m above sea level at the culmination of the Naptowne Glaciation. An extensive piedmont glacier which probably was confluent with other major ice streams extended well eastward onto the continental shelf. If the basal sediment at Section S2 is glacial marine, and eustatic sea level was lower during glacial retreat, this suggests that the central portions of Chinitna Bay were isostatically depressed below sea level at that time. Continued rebound may have caused a regression of the shoreline which was superimposed on the late Pleistocene-early Holocene eustatic marine transgression. If the sediments which cap Gull Island are loess, they imply that the regression associated with isostatic rebound may have brought the floor of Chinitna Bay above present sea level; meltwater streams may have flowed eastward at this time, serving as a source area for windblown sediments. Continued Holocene transgression may have resubmerged the floor of Chinitna Bay after isostatic recovery was complete, but the water level did not rise as high as the Gull Island abrasion platform.

The basal beach gravels in Sections s6 through s12 suggest that a minor marine regression occurred during middle-late Holocene time. Following deposition of the gravels, salt marsh sedimentation with periodic episodes of subaerial exposure was widespread. Following deposition of the salt marsh complex, a widespread marine regression occurred. This latest regression was probably caused by westward tilting of the area between Gull Island and Park Creek.

THE "EARLY MAN" ARCHEOLOGICAL SITE IN CHINITNA BAY

1. Hibben's Description

The Chinitna Bay archeological site was reported to extend for approximately 2.4 km along the western and southwestern side of the bay (Hibben 1943:257). Based on the 1978 fieldwork and the relocation of Hibben's photo localities, with reference to modem topographic maps, it has been ascertained that the compass directions originally recorded for the site area were in error. The center of the area described by Hibben is located on the south side of Chinitna Bay approximately 0.8 km southwest of Seal Spit. Along the 2.4 km of site area, Hibben stated that "material is not exposed for all of this distance, nor are signs of habitation continuously visible," however, "chips were grouped in concentrations throughout the entire extent of the site, as though marking chipping areas," and "by following these various strata along the upper beach where they are exposed, it is evident that the habitation level throughout the mile and a half extent, if this can all be considered one site, rises and falls as though the site were originally on several low hills or knolls along the shore" (Ibid. :257-259). Cultural material was reported in situ and eroding from "a dark colored stratum of humus, which immediately overlies a hard, compact, iron-stained blue clay layer, which forms extensive portions of the beach along this side of the bay" (Ibid. :258). Lithic artifacts, consisting mostly of chips, and charred wood were reported to occur sporadically throughout the site area, but were concentrated at the southeastern end near the small creek. Bone material, while not abundant, was reported from the southern portion of the site area. Mammoth was said to be the only species identified from the bone fragments recovered. It is unclear whether any of the bone material was actually located in situ, since Hibben does not specifically say this in his 1943 article. In a recent letter Hibben (Written Communication 1978a) states that the mammoth bones were awash in the surf. In a somewhat more popularized account of his field investigation in Chinitna Bay, Hibben (1946:125) does, however, state that "protruding here and there from the bank, or shattered in sodden fragments on the beach, were the bones of mammoths." Although no report is available on the analysis of the bone material recovered at Chinitna Bay, Hibben recently stated (Written Communication 1978b) that the identification was made by Dr. Chester Stock (paleontologist at the California Institute of Technology until his death in 1950).

A generalized description of the stratigraphy at the Chinitna Bay site was presented by Hibben (1943:258). Five geologic strata were discussed, which from lowest to highest are (stratum designations not given by Hibben): Stratum V -- the lowest stratum described consisted of "a hard, compact, iron-stained blue clay layer, which forms extensive portions of the beach along this side of the bay." Stratum XV -- immediately overlying the blue clay "the habitation layer is marked by a dark colored stratum of humus," and "sporadic tree stumps marked the humus layer of the occupation level as these were being exposed. Roots and occasional whole stumps were upright and apparently in original growing position." Stratum III -- "immediate ly superimposed on top of the humus and the occupation level, was a layer of muck of loess-like consistency. The muck varied in thickness from 4 feet at the south end of the site near the creek mentioned before, to 22 feet near the center and north end." Stratum II -- "near the top of the muck layer, a volcanic ash 3 inches thick could be sporadically traced." Stratum I -- superimposed as a capping on the muck layer was a considerable stratum of peat of apparently modern origin, which extended up to and including the grass roots and the peaty layers of the present surface. This peaty layer varied considerably in thickness, from 1 foot to 6 feet, and also was not visible throughout the entire length of the site."

Individual stratigraphic sections within the site area were not described by Hibben, and it is assumed that his stratigraphic sequence was a composite of the major units which he observed over the entire site area. No single geologic section examined during 1978 conformed totally with the stratigraphic sequence reported earlier by Hibben.

2. Results of the 1978 Investigation

It can be clearly demonstrated on geologic and archeological grounds, as well as the relocation of Hibben's (1943) photo localities, that testing and stratigraphic analysis were done in the same area in which the Chinitna Bay archeological site was reported. On the basis of stratigraphic associations, and interpretations documented in this report, it is difficult to reconcile the geological findings of the 1978 study with the existence of the early archeological site reported by Hibben at Chinitna Bay. Furthermore, no prehistoric archeological materials or cultural evidence of any age was located anywhere along the southern shore of Chinitna Bay during the 1978 field investigation.

Stratigraphic Section S2 almost certainly marks the western end (Hibben's northern) of the Chinitna Bay site. This section corresponds well with the peat, ash, muck, and blue clay sequence described by Hibben. The Section S2 was found to contain from the top down, peat, volcanic ash, brown clayey sediments of marine origin, and a gray clayey silt which has a slightly blue color (see Appendix III-A) .

At the eastern end of the site area (Hibben's southeast) Section S6 has the appearance of the peat, muck, blue clay sequence which Hibben describes at this end of the site. However, this section consists of a brown clayey silt of marine origin below a peat layer with a lower blue-gray silt, and these silts actually represent oxidized and unoxidized layers of marine deposits. The area along the beach where S6 is located has experienced wave cutting identical to that described by Hibben at the southeast end of the site, and the S6 area looks identical to the section shown by Hibben in Plate XIVC (1943). Several other factors which argue for the immediate vicinity of Section S6 being the location of the western end of the site include (1) s6 is located near Sinking Creek which may be the small unnamed creek mentioned by Hibben; (2) Section S7 nearby contains similar strata to that of s6, but additionally contains a thin organic layer separating the upper brown clayey silt (Hibben's muck?) from a lower, less oxidized clayey silt, end could be the humus stratum which was identified as the cultural layer; (3) tree stumps can be seen along the exposed area which, while not in situ, are sitting upright with bases at the approximate level of the contact between the upper brown clayey silt, and the lower blue-gray clayey silt.

It can also be argued on stratigraphic grounds that Section S12 west of Sea Otter Point marks the western end of the site area. From the top down, this section contains layers of brown colluvium, humus, bluish clayey silt, and brown clayey silt. This section is similar to the stratigraphy described by Hibben in that it contains a blue clayey layer with a humus on top and tree stumps in place, however it is difficult to correlate the upper brown colluvium, which contains clasts ranging from silty rubble to boulder size, with the muck layer described by Hibben.

The stratigraphic unit described as muck by Hibben, if traced laterally along the entire site area, probably contains a variety of deposits including oxidized salt marsh sediments, bouldery mudflow deposits, and altered volcanic debris. The blue clay which Hibben describes throughout the site area actually consists of two separate deposits. The blue clay in Section s2 at the *western* end of the site appears to be glacial marine drift in origin, while in the central and eastern portions of the site the exposed blue clay represents unoxidized salt marsh deposits.

Radiocarbon dates (Table III-1) demonstrate that the sediments near Hibben's "mammoth locality" are of very late Holocene age. No mammoth remains have been described elsewhere in Alaska which are younger than 15,000 years B.P. (Guthrie 1976) . Furthermore, no pre-Holocene unconsolidated sediments which could seine as a source for mammoth remains occur along the southern shore of Chinitna Bay. The extremely young age and marine origin for sediments in the site area suggest that mammoth did not inhabit the area during sediment deposition. The only large mammal bones of comparable size found in the site area during 1978 were the remains of two beluga whales which were washed into the tidal mud flat southwest of Seal Spit.

The Chinitna Bay archeological site was reported to extend over a considerable distance of the shoreline. If this were the case, human occupation would have occurred on salt marshes during their formation in the late Holocene. A suite of four radiocarbon dates demonstrate that the deposition is no older than 500 or 600 years B.P. in the site area. It seems unlikely that ancient deposits which could serve as the provenance for an early archeological site exist along the southern shore of Chinitna Bay.

SUMMARY

Geological and archeological investigations were conducted along the south shore of Chinitna Bay during June of 1978, in an attempt to relocate and test an early archeological site reported by Frank C. Hibben (1943). During fieldwork, it was possible to relocate Hibben's (1943) photo localities, as well as the general geologic strata which he described for the site area. However, no prehistoric cultural evidence was found along the southern shore during archeological reconnaissance and testing. Geological analysis coupled with radiocarbon dates on key strata in the reported site area demonstrate that the deposits which Hibben described are of very late Holocene age. Based on data from the 1978 investigations, it appears quite certain that no early archeological site or geological strata from which mammoth remains could be derived exist anywhere along the south shore of Chinitna Bay.

APPENDIX III-A

MEASURED STRATIGRAPHIC SECTIONS ALONG THE SOUTH SHORE OF CHINITNA BAY*

Exposure Height Above Sea Level (cm)	Unit	Thickness (cm)	Description
COFFIN CREEK; S1			
676	1	5	Organic mat. Partly decomposed grass and mixed organics.
	2	40	Silt. Dark yellowish brown (10YR 4/4) slightly clayey silt. Minor oxide concretions near base. Diffuse lower boundary.
	3	105+	Silt. Dark gray (10YR 4/1) slightly clayey silt. Minor oxidized zones included in unit.
PARK CREEK; S2			
1,886	1	10	Organic mat. Partly decomposed moss, brush, and spruce needles. Common modern roots.
	2	5	Peat. Black (10YR 2/) very peaty silt-fine sand. Peat sample from base (UA78-73-1) yielded radiocarbon date of 600 ± 100 years B.P. (GX-5654). Conformable lower contact.
	3	3	Tephra. Brown (7.5YR 4/4) powdery ash with 1 mm diameter lapilli fragments.
	4	40	Peat. Very dark brown very peaty sandy silt grading downward to highly organic stained mixed silty clay. Gradational lower contact.

*Refer to Figure III-4 for locations of geologic sections.

Exposure Height Above Sea Level (cm)	Unit	Thickness (cm)	Description
PARK CREEK; S2 (continued)			
	5	280	Rubbly sandy clay. Mottled strong brown (7.5YR 4/8) to brown (10YR 4/3) interbedded clay, sandy clay, clayey sand, and rock rubble. Pure clay beds to about 10 cm thick. Sand layers more irregular, and composed largely of powdery white lapilli fragments. Rubble layers lenticular, and consist of angular sandstone and pelitic rock fragments. Unit deeply penetrated by common cylindrical oxidized root casts to 1 cm diameter. This organic layer near middle.
	6	180	Muddy gravel. Strong brown (10YR 5/6) stained angular monolithologic (graywacke) rock fragments to 25 cm diameter in mixed granule-clay matrix. Unit commonly firmly cemented, especially near sharp conformable lower contact.
	7	300+	Clay. Dark gray (2.5Y 4/0) massive unbedded silty clay and clayey silt with common rounded to angular clasts of variable lithology. Rounded quartz granules and pebbles common. Unit unbedded but contains stony and sandy horizons. Lower contact covered.
DROWNED PLATFORM; S3			
564	1	5	Organic mat. Modern grass with isolated piles of stony silty clay on surface. Gradational lower contact.
	2	50+	Stony silt. Dark gray (10YR 4/1) slightly clayey silt. Black organic material in well defined 1 cm-thick layers is common with depth. Commonly contains isolated lenses of angular rock fragments or .

Exposure Height Above Sea Level (cm)	Unit	Thickness (cm)	Description
DROWNED PLATFORM; S3 (continued)			
			individual clasts to 25 cm diameter. Isolated wood fragments to 10 cm diameter also common. Unit compact and forms bench where undercut by waves. Very rare small marine pelecypods in situ. Sample of wood (UA78-73-2) from the basal exposure yielded a radiocarbon date of 375 ± 120 years B.P. (GX-5655).
COVEY CREEK; S4			
594	1	5	Organic mat. Modem grass. Sod denser and better drained than at Section S3.
	2	50+	Stony silt. Very similar to Unit 2 of Section 3 but oxidized near surface and more compact.
SEAL SPIT: S5			
	1	60	Beach gravel. Gray very loose monolithologic (graywacke) subangular to surrounded fine shingle gravel with a strong subhorizontal fabric. Upper surface forms modern beach bar.
	2	50	Silt. Strong brown (1OYR 5/6) to dark gray (1OYR 4/1) slightly clayey silt. Color varies as subhorizontal lenses of gray silt within brown silt. Unit inludes at least two thin lenses of monolithologic fine gravel. Peaty near top.
	3	40+	Beach gravel. Oxidized gray partially cemented monolithologic subangular to subrounded fine shingle gravel. Upper surface appears to form ancient beach bar.

Exposure Height Above Sea Level (cm)	Unit	Thickness (cm)	Description
CAMP POINT; S6			
856	1	5	Organic mat. Dense modern grass. Minor gray gravel and rounded driftwood fragments on surface.
	2	175	Silt. Similar to and grades downward into Unit 3 but thoroughly oxidized yellowish brown. Oxide cemented root casts to 2 cm diameter (horsetail) are very common and clearly form by serving as post-depositional aquifers in clayey silt (they are contemporaneous with deposition). Unit well bedded.
	3	270	Silt. Dark gray (1OYR 4/1) clayey silt with common isolated layers and lenses of subangular fine gravel. Texturally variable, ranging from very stony horizontally bedded silty clay at base to silty clay. Organic matter commonly dispersed in silt and occasionally in discreet layers where it forms resistant benches on beach. Contains randomly oriented in situ terrestrial and marine fossils of wood and gastropod (*Neptunia*?) respectively. Upper portions of unit are well bedded, with clearly defined folds with amplitudes of up to 50 cm.
	4	20+	Grave 1. Oxidized gray horizontally bedded partially cemented monolithologic subangular to subrounded fine shingle gravel in slightly clayey silt matrix. Minor irregular lenses of stony silt beds.

Exposure Height Above Sea Level (cm)	Unit	Thickness (cm)	Description
SINKING CREEK WEST; S7			
846	1	5	Organic mat. Lush grass with willow, mature spruce, and cottonwood trees. No storm-tossed detritus on surface.
	2	85	Silt. Slightly mottled dark yellowish brown (10YR 4/4) horizontally-zoned silt with minor silty clay. Thoroughly mixed by modem roots.
	3	73	Interbedded unit. Dark yellowish brown silty clay, clayey fine sand, and well-washed, well-sorted fine sand in continuous 1-4 cm thick beds. One 10 cm thick dark yellowish brown silt bed similar to lower unit. Gradational arbitrary lower contact. Living horse-tail roots to 150 cm depth.
	4	76	Silt. Mottled grayish brown (10YR 4/2) to yellowish brown (10YR 5/6) clayey silt and silty clay. Unit massive with no bedding apparent. No gravel or granule-sized clasts present.
	5	3	Peaty silt. Dark gray (10YR 4/1) clayey silt with minor silty fine sand. Contains no clasts larger than fine sand. Unit extremely rich in organics with common grassy peat, organic-stained zones, and large wood fragments to 5 cm diameter. Sample of compressed log (UA78-73-3) yielded radiocarbon date of 300 ± 130 year B.P. (GX-5656). Upper-and lower contacts extremely sharp; organics appear to control oxidation boundaries.
	6	6	Silt. Uniformly oxidized yellowish brown (10YR 5/6) clayey silt and clayey fine sand.
	7	5+	Grave 1. Angular platy monolithogic fine gravel in muddy matrix.

APPENDIX 111-A. continued

Exposure Height Above Sea Level (cm)	Unit	Thickness (cm)	Description
SINKING CREEK MOUTH; s8			
866	1	10	Organic mat. Lush, grassy, thickly forested (spruce and poplar) upper surface above storm limit.
	2	55	Silt. Dark yellowish brown (1OYR 5/4) clayey silt. Horizontal structure present in places. Mixed by slumping and modern root penetration.
	3	20	Solum. Silty clay of irregular thickness. Pronounced solum consists of dark reddish brown 3 an-thick clayey horizon overlying yellowish brown (1OYR 5/6) clay.
	4	33	Grave 1. Silty clayey, poorly structured fine monolithologic graywacke gravel with strong horizontal fabric. Thin sand layer at sharp basal contact.
	5	52	Silt. Dark yellowish brown (1OYR 4/4) silty clay and clayey silt with minor clayey sand zones. Several gravel clasts near base, but they possibly are intruded from below. Pronounced 0.5-5.0 cm thick convoluted organic stained dark gray solum at top of unit. Occasional grassy peat and woody layers.
	6	5+	Grave 1. Monolithologic angular graywacke poorly exposed gray gravel.
SINKING CREEK EAST; S9			
906	1	10	Organic mat. Lush, grassy, thickly forested (spruce only) upper surface above the storm limit. Draped over older sediments.

Exposure Height Above Sea Level (cm)	Unit	Thickness (cm)	Description
SINKING CREEK EAST; S9 (continued)			
	2	20	Silt. Dark yellowish brown clayey silt thoroughly mixed by modern roots. Gradational lower contact.
	3	125	Interbedded unit. Complex interbedded unit is dominantly dark yellowish brown clayey silt and silty clay but has common interbeds of well-sorted, very fine sand and fine sand. Contains one layer of rounded-subrounded pebbles and granules which is clearly cut into a 10 cm thick fine sand layer. Also contains two 1 cm-thick layers of subrounded platy mudrock gravel which are identical to the gravel in Sinking Creek. Contains one thin layer of organic silt near middle.
	4	55	Silt. Mottled unbedded clayey silt. Contains charcoal in one place. Gradational lower contact. Horizontally segregated ice lenses to 5 cm thick present.
	5	5+	Grave 1. Poorly exposed platy monolithologic subrounded gravel in muddy matrix.
BLUFF WEST OF BASE CAMP; S10			
1,077	1	5	Organic mat. Lush grass and cottonwood forest above the storm limit.
	2	35	Silt. Brown clayey silt with occasional silty and clayey zones. Horizontal soil fabric common. Thoroughly mixed by modern roots.
	3	205	Interbedded gravel, silt, and paleosols. Gravel consists of monolithologic graywacke, angular, platy, well-sorted clasts.

Exposure Height Above Sea Level (cm)	Unit	Thickness (cm)	Description
BLUFF WEST OF BASE CAMP; S10 (continued)			
			Almost no clasts smaller than granule or larger than pebble size are present. Silt is generally devoid of gravel, is very clayey, and commonly has zones of clayey fine sand. All silt beds appear texturally similar, but lower have thin layers of fine" gravel. Brown clayey silt completely fills the voids in the gravel units. Paleosols are 1 cm-thick beds of finely divided organic matter with no visible plant fragments. Thin gray (leached?) zones below or above undulose paleosols. Variations in thickness and slight inter-tonguing of units appear due to soft sediment deformation during compaction.
	4	10+	Grave 1. Gray monolithologic graywacke, loose shingle gravel with minor clayey silt matrix. Appears identical to modern beach gravel.
BEACH RIDGES; S11			
1,127	1	200	Covered. Extensive topographic platform lies 2 m above the crest of the oldest beach ridge and is thickly forested. The platform sediments which are nowhere exposed are cut into and overlain by the beach ridges, and are stratigraphically older.
	2	400	Beach ridges. Seven major beach ridges about 0.3 to 2.0 m high extend seaward for a distance of about 45 m along a straight segment of coastline. They are generally asymmetric with a steeper seaward face. The following relations indicate a progressive increase in age shoreward: (1) they become more thickly vegetated, (2) trees are larger, with

APPENDIX III-A. continued

Exposure Height Above Sea Level (cm)	Unit	Thickness (cm)	Description
BEACH RIDGE; S11 (continued)			
			tie oldest three ridges showing spruce tree diameters of 50 cm, 20 cm, and 7 cm respectively, (3) ridge slope angles decrease, (4) gravel is more oxidized, and (5) driftwood is more decayed.
LANDSLIDE LOCALITY; S12			
	1	1,000+	Rubble. Unsorted, unwashed angular blocky monolithologic very silty rubble to boulder size. Texturally variable, with common subhorizontal fabric shown by small boulders. Minor organic matter present includes deformed peaty zones and wood fragments. Lower contact sharp and appears erosional because the lower 20 cm of unit contain portions of the underlying unit.
	2	30	Organic silt. Generally clayey silt with rare fine sand and clay zones. Common ly dark gray (5Y 4/1) fetid smelling, and organic rich, but diffuse dark yellowish brown oxide staining is common in some zones, especially where organics appear absent. Organics common throughout most of unit but two pronounced 2 cm-thick beds of dense peat and compressed wood fragments lie near the top and base of unit. Sample of wood (UA78-73-5) from the top of the unit yielded a radiocarbon date of 285 ± 100 years B.P. (GX-5658). Very pronounced strong brown (7.5YR 5/8) 2 cm-thick oxidized horizon at top of unit is penetrated by modern roots.
	3	110	Silt. Yellowish brown slightly clayey silt and clayey silt. No major textural break at sharp upper contact but small oxide concretions are present. Poorly exposed but appears massive.

APPENDIX III-A. continued

Exposure Height Above Sea Level (cm)	Unit	Thickness (cm)	Description
LANDSLIDE LOCALITY; S12 (continued)			
	4	10+	Grave 1. Gray monolithologic graywacke subangular, well-sorted fine gravel with mud matrix. Appears identical to modern beach gravel.
SEA OTTER POINT; S13			
	1	10, 000+	Bedrock. Bowser Formation. "Massive sandstone and conglomerate containing thin interbeds of siltstone and shale." Middle(?) and Upper Jurassic in age (Detterman and Hartsock 1966).
GULL ISLAND; S14			
1,376	1	20	Organic mat. Thick sod cap beneath lush grassy surface.
	2	60	Interbedded unit. Interbedded very dark grayish brown (10YR 3/2) organic stained silt with minor isolated rounded granules and small pebbles, dark yellowish brown (10YR 4/4) oxide stained silty fine sand, dark reddish brown (5YR 3/3) well rounded and sorted medium-grained quartzone sand, and black silt and finely divided organic matte r. Very peaty dark upper surface grades downward first to a 15 cm thick organic stained silt unit, then to a complex of thinner interbeds. Reddish brown sand layers sharply overlie organic stained silt. All units contain finely divided oxides and organic matter. Sample of highly organic very fine" sand (UA78-73-4) from near the base of unit yielded a radiocarbon date of 4,190 ± 155 years B.P. (GX-5657).

Exposure Height Above Sea Level (cm)	Unit	Thickness (cm)	Description
GULL ISLAND; S14 (continued)			
	3	50	Gradational unit. Light olive gray slightly clayey silt grades down to rock rubble, coarse rock rubble, and finally to the underlying bedrock.
	4	1,250+	Bedrock. Pomeroy Arkose Member. "Massive light gray arkose and arkosic conglomerate; minor interbeds of siltstone." Upper Jurassic in age (Detterman and Hartsock 1966).

APPENDIX III-B

RESULTS OF SEDIMENT ANALYSIS
FROM GULL ISLAND SAMPLE 6/6/78 #1

Percentages of Fractions

Gravel	Sand	Silt	Clay	Sand/Mud Ratio	Shepard Class	Tetrah. Group
1.21	35.81	47.29	15.69	0.59	3	21

Phi Sizes at Percent Levels

1%	5%	16%	25%	35%	50%	65%	75%	84%	95%
-1.26A	1.27A	2.51A	3.14A	3.92A	4.94A	6.01A	6.93A	7.96A	9.99A

Trask Values

Q1	Q2	Q3	SQ	LOG SO	SKG
0.114	0.033	0.008	3.729	0.572	0.936

Inman Values

Medium	Mean	Dev.	Skew.	2nd Sk.	Kurt.
4.94	5.23	2.73	0.11	0.25	0.60

Folk and Ward Values

Mean	Dev.	Type	Skew.	Type	Kurt.	Type
5.14	2.68	5	0.13	4	0.94	3

Moment Measures (without Sheppard corrections)

Mean	St. Dev.	Skew.	Kurt.
5.19	2.82	0.37	3.18

IV. HISTORICAL SYNOPSIS OF TERRESTRIAL ARCHEOLOGICAL RESEARCH IN REGIONS ADJACENT TO THE STUDY AREA.

E. James Dixon, Jr.

REVIEW OF ARCHEOLOGICAL RESEARCH

Linguistically the study area was a polyglot at the time of contact with Euro-American cultures. Eyak speakers occupied the extreme eastern portion of the study area in the vicinity of Cape Suckling and farther to the east. Chugach Eskimos lived in Prince William Sound and along the eastern flank and the extreme southern end of the Kenai Peninsula. Tanaina Athapaskans had settled along the shores of Cook Inlet, and Eskimo speakers occupied the extreme southwestern coast of Cook Inlet south of Iliamna Bay along the southern margin of the Alaska Peninsula.

There exists a somewhat surprising void in the quantity of research and consequently the quality of data relevant to understanding the prehistory of the study area (Figure VI-l). Several writers (von Wrangell 1839, Petroff 1880, Dan 1877, and Osgood 1933) noted the rather unusual circumstance that the Cook Inlet region was occupied by Athapaskan Indians (the Tanaina) and that Prince William Sound was occupied by the Chugach Eskimo. All have suggested displacement of Eskimo peoples by the Tanaina in the Cook Inlet region based on oral history of the local inhabitants. Utilizing both archeological and historical data, Dumond and Mace (1968) have suggested that Tanaina Athapaskans may have replaced the Pacific Eskimo in upper Cook Inlet sometime between A.D. 1650 and A.D. 1780. The reasons for replacement are not clear.

Prince William Sound has been identified as an area that was occupied in prehistoric as well as historic times by Chugach Eskimo peoples (Birket-Smith 1953, de Laguna 1956). The boundaries between the Chugach Eskimo and other native groups may have shifted through time and the eastern area of Prince William Sound may have at times been occupied by Eyak Indians (Birket-Smith 1953:18-19). Although Hrdlicka (1930) traveled through

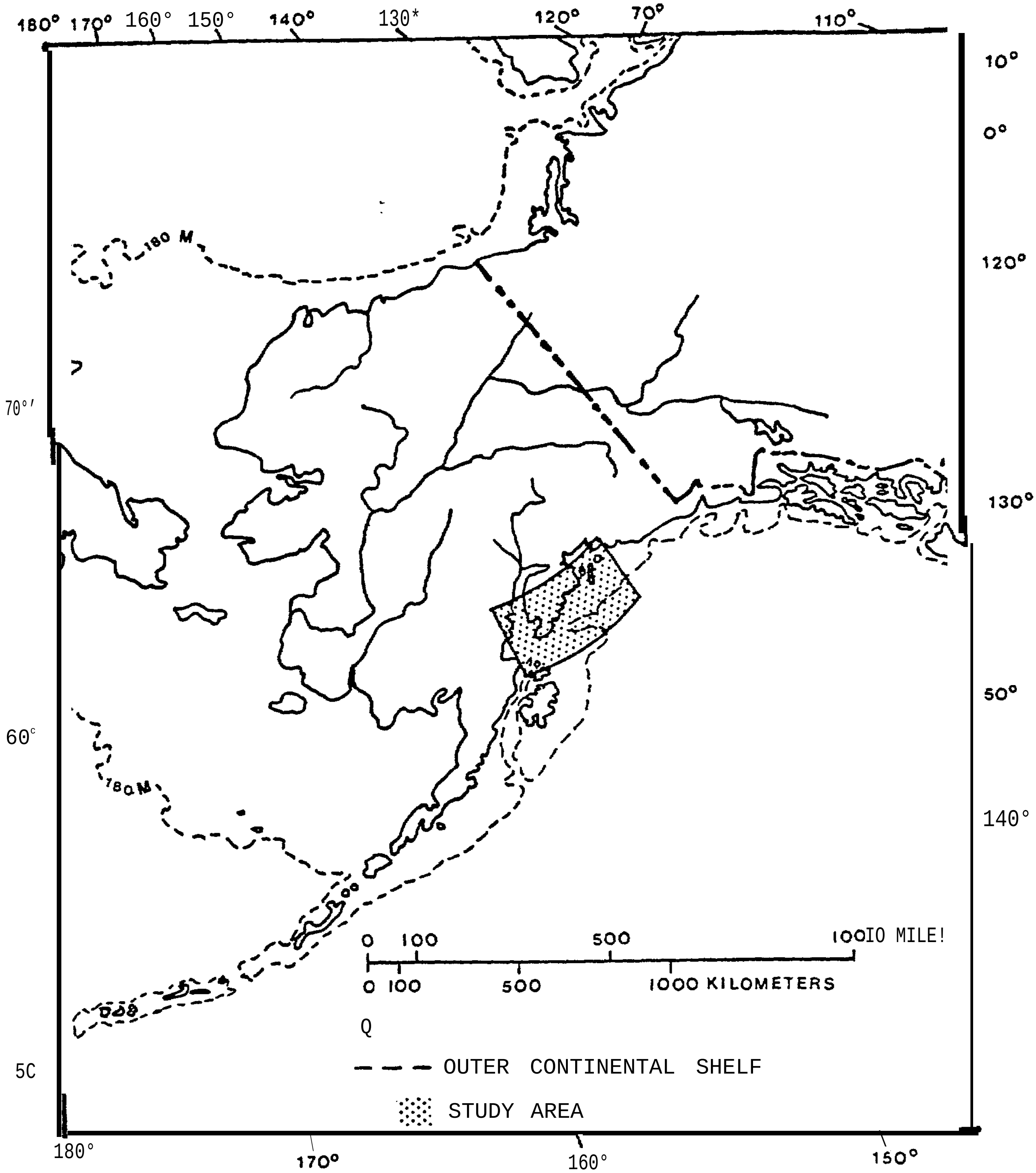


Figure IV- 1. Lower Cook Inlet Cultural Resource Study area.

Prince William Sound stopping at Cordova, Valdez, Seward, and Anchorage en route to the Yukon River drainage during his 1926 anthropological survey of Alaska, he apparently did not record the location of any prehistoric sites in the Prince William Sound/ Cook Inlet region with the possible exception of a later period cemetary at Cordova (ibid 35-36).

Archeological surveys were conducted in selected areas of Prince William Sound by Frederica de Laguna in 1930 and 1933, by U.S. Forest Service archeologist Douglas Reger in the early 1970's, by John E. Lobdell in 1976 (Lobdell 1976), and by David Plaskett and James Dixon in 1977 (Plaskett, 1977). Most of the archeological site locations recorded for the Prince William Sound regions are based on information obtained from native informants or longtime residents of the area. As a result, many of the known site locations areof historic age, and the prehistoric past is less well documented.

Frederica de Laguna (1956:60-65) developed a four period chronology for the prehistoric and historic Chugach Eskimo of Prince Willaim Sound. This chronology is based primarily on artifact types in stratified layers, from older to younger, excavated at the Palugvik archeological site on Hawkins Island, and from early historical documents. The earliest period of Chugach Eskimo culture described by de Laguna is the Older Prehistoric Period. This period is characterized at Palugvik by incised slate plaques, the relative scarcity of artifact types characteristic of later period and by considerable decomposition of the midden (ibid 64). This layer has been radiocarbon dated to 1753 $\pm$ 105 and 1727 $\pm$ 105 BP (Rainey *and* Ralph, 1959)-. The second period of Chugach prehistory is the Later Prehistoric Period, and is characterized by the presence of native copper, a relative abundance of fire cracked rocks, splitting adzes, barbed slate projectile points, and by the-absence of objects of foreign manufacture (ibid 64) . The Protohistoric period is the third period described by de Laguna and is comprised of the artifact types found in the Later Prehistoric Period, the addition of "Cook type" trade beads, and theoretically by small amounts of iron (ibid 64) . The final period defined by de Laguna is the Historic Period and is marked by "Glacier Island Type" beads, an abundance of non-native goods, evidence of introduced diseases, and Christain burial customs (ibid 64). De Laguna's pioneering work in Prince William Sound in the early 1930's still provides the only cultural chronological sequence for the Sound.

Although later radiocarbon analysis (Rainey and Ralph 1959) have established temporal placement for the earliest period defined by de Laguna to approximately the beginning of the Christain era, it is extremely plausable that the prehistory of the Prince William Sound probably reflects the paucity of archeological research undertaken in the Sound rather than lack of occupation by man during earlier periods.

Across the Kenai Peninsula, to the West of Prince William Sound, lies Cook Inlet. Pioneering archeological research in Cook Inlet and Kachemak Bay regions was accomplished by Frederica de Laguna during the summers of 1930, 1931, and 1932. During the summer of 1930, de Laguna conducted preliminary surveys along Knik Arm at Fish Creek, Knik, and Eklutna. During the same year she visited sites south of Fire Island, the Tyonic District, and surveyed along the southwestern shore of the Inlet (de Laguna 1975:8). De Laguna returned to Cook Inlet in 1931 and focused excavation efforts on two sites; one located at Cottonwood Creek and the other on Yukon Island in Kachemak Bay (ibid 9). Yukon Island was again the site of concentrated excavation in 1933, and during that summer de Laguna also conducted brief archeological surveys between Chinitna and Tuxedni Bays, Port Graham, and also visited several minor sites in Kachemak Bay (ibid) .

De Laguna's field work and subsequent analysis led to the delineation of several culture periods which preceded Athapaskan Indian culture in the Cook Inlet area. These culture periods were named -from the oldest to youngest -Yukon Island I, II, sub-III, and IV (de Laguna 1975:29). The Yukon Island sequence has become the type sequence for the Kachemak Tradition and most researchers now use the terms Kachemak I, II, sub-III, and III when describing prehistoric material culture from the Cook Inlet regions. These Kachemak Tradition culture periods are derived directly from de Laguna's Yukon Island sequence. Some of the more diagnostic material cultural traits of the Kachemak tradition are: 1) notched and grooved line sinkers, 2) toggle harpoons, 3) composite socket pieces, 4) barbed dart heads, 5) compound fishhook barbs, 6) ground slate knives and ulus (often notched) , 7) stone lamps, and 8) labrets (de Laguna 1975:121-131).

William Workman (1977) has attempted to establish a tentative chronological framework for the Kachemak tradition based on the relatively scanty radiocarbon data available for the Cook Inlet region. He (ibid:33) suggests a second millennium A.D. temporal placement for Kachemak IV, which he has added to de Laguna's three major period sequence. Kachemak IV period is as yet undated but represents a somewhat nebulous artifact assemblage containing native copper, triangular slate end blades, and potsherds. It may represent the remains of both post Kachemak tradition Pacific Eskimos and early Tanaina Athapaskans (ibid). A temporal span between A.D. 800 through A.D. O is proposed for Kachemak III, A.D. O and 400 B.C. for Kachemak sub-III, A.D. 1,200 to 400 B.C. for Kachemak II, and Kachemak I is ascribed temporal placement to sometime during the second millenium B.C. (ibid:35-35).

De Laguna has provided a concise summary of archeological field research undertaken between 1934 and 1975 in her Preface to the 1975 reprint of "The Archeology of Cook Inlet, Alaska" (de Laguna, 1975: iii-xi). Some of the more significant archeological work reported here is: the discovery of several pit houses by Gordon Marsh in 1956 near English Bay; an archeological survey and limited test excavations along Knik Arm under the direction of Albert Spaulding during the summer of 1966 (ibid: Dumond and Mace 1968); the discovery and subsequent excavation of a noncoastal Norton tradition Eskimo site on the Kenai River (Reger, 1973, 1977); the discovery of several archeological sites with the State

Park System on the Kenai Peninsula (Dixon and Johnson, 1972) ; excavations at Cottonwood Creek under the direction of William Workman during the summer of 1974; testing and subsequent excavation at Chugachik (Indian) Island by Karen Workman (de Laguna *1975:* viii, K. workman, *1977)* and additional archeological excavations carried out at the Yukon Island site by William and Karen Workman, Lobdell, and de Laguna during the summer of 1978.

This research, taken collectively, has provided additional data pertinent to archeological site distributions in the Cook Inlet region, enlarged understanding of both Kachemak tradition and late prehistoric Tanaina culture, and probably of most significance, has led to the establishment of a tentative cultural chronology for the Cook Inlet region as well as inter-regional comparisons. Although this work is significant, many important anthropological problems remain unresolved. The Cook Inlet region will require much future work before the cultural chronology is firmly established and the mechanisms of population replacement, diffusion, and <u>in situ</u> cultural development so pertinent to the region are adequately addressed.

As can be realized from this brief discussion of the cultural chronology and the *review* of field work in the Cook Inlet region, only the skeleton, missing several critical elements, of a cultural chronology is available for the past several thousand years. In attempting to address problems of early man in the study area, and the possibility of archeological site occurrence on the Outer Continental Shelf, the scanty information available presents little data with which to work. The only Pleistocene age archeological site reported for the region is the Chinitna Bay site (Hibben 1943) , and it has been demonstrated (Thorson, Plaskett, and Dixon, this report) that this site report probably resulted from both misidentification of faunal remains and a poor understanding of the geological processes at the site locale. However, there do exist additional data which strongly suggest very late Wisconsin/early Holocene occupation of the study area. In addition, there are archeological data both west and east of the study area which indicate that the Gulf of Alaska was occupied approximately 10,000 years ago.

Immediately to the west of Cook Inlet, Dumond (1971) and Henn (1978) have described the Ugashik Narrows Phase which is documented through radiocarbon chronology to span the period between 9,000 and 7,500 years ago. This information establishes a minimum limiting date for human occupation west of Cook Inlet and it is reasonable to assume that even earlier evidence of human occupation will be discovered on the Alaska Peninsula as research there progresses. East of the study area, the Ground Hog Bay site near Juneau and the Hidden Falls site near Sitka have been discovered which date ca. 10,000 B.P. and 9,500 B.P., respectively (Ackerman 1968, Davis 1979). These data strongly suggest that as additional research is carried out in south central Alaska, archeological sites exhibiting similar temporal placement will be discovered.

Directly within the Cook Inlet region, de Laguna (1975:vii) reports artifacts which may possibly relate to the Arctic Small Tool Tradition, which the late Louis Giddings tentatively compared to the Gomer Period on the Alaska Peninsula (ea. 3,900-3,000 B.P.). These finds were made in, or adjacent to, Halibut Cove. In addition, Reger (1978) has rePorted a multicomponent site located on Turnagain Arm. It has been named the Beluga Point site. In reference to early man research it is the most significant archeological site discovered in the Cook Inlet region. The site exhibits 6 cultural components, which are: 1) a microblade bearing component, 2) a stemmed point component, 3) a Kachemak III related component, 4) a Norton related component, 5) a lanceolate point component, and 6) a level represented only by a large scraper which has been radiocarbon dated to 4,155 B.P. (Reger 1978:1). Of greatest significance to this study is the in situ documentation of a microblade component which Reger (personal communication) believes may be related to the Denali Complex of Interior Alaska. Based on comparison, it is not unreasonable to assume that the microblade component at the Beluga Point site may be approximately 10,000 years old. The Denali related component may document the movement of Denali peoples from Interior Alaska into the Cook Inlet area following deglaciation of the high alpine passes of the Alaska Range.

Based on the preceding review of the archeological data, it does not appear unreasonable that both Cook Inlet and Prince William Sound were occupied 10,000 years ago. It is possible that human occupation of the study area may have occurred prior to that time. The lack of archeological data pertinent to late Wisconsin and early Holocene human utilization of these vast regions is probably the result of two factors: 1) extremely little archeological research, particularly with an early man focus, has been undertaken in the study area, and 2) possibly much of the area which was ice free and consequently available for human occupation during Wisconsin and early Holocene times is now the continental shelf which has been submerged as a result of post Wisconsin sea level rise.

Glaciation and Human Occupation of the Study Area

Since Prest (1969) , of the U.S. Geological Survey, produced a map which depicts the entire Outer Continental Shelf of the Gulf of Alaska and the Northwest coast as ice covered at approximately 15,000 B.P., most geologists and archeologists have taken this information at face value and have regarded the Northern Pacific Rim of North America as an area with no potential for human occupation prior to 15,000 B.P. Additionally, this portrayal of ice cover has eliminated the Pacific Rim of Alaska and Canada as possible migration route for man entering the Americas during Pleistocene times (from the minds of many anthropologists). However, as recent data accumulates, many scholars are reconsidering the Northern Pacific Rim as a potential route of entry for man in the New World.

Fladmark (1978; 1979) has presented a series of arguments which question previously accepted theories regarding extent of glaciation along the Northwest Coast and present data which strongly counters the impossibility of the Northwest coast as a migration area into the Americas. Fladmark's data include: 1) bottom sediment analysis and radiocarbon chronology, 2) interpretation of submerged geomorphic features, 3) postulated ice tongues rather than ice-sheet coalescence, 4) a record of unglaciated regions on islands during the last glaciation, 5) biotic refugium on islands - plant taxa and Rangifer dawsoni on the Queen Charlotte Islands, 6) postulated unglaciated headlands, divides, and outer islands in extreme Southeast Alaska, 7) less glaciation in the Saint Elias range during Wisconsin times than during Neoglacial times due to continuing orogeny, 8) data suggesting that Prince William Sound is presently more intensely glaciated than it was during Wisconsin times, 9) the possibility that unglaciated areas of Prince William Sound and Cook Inlet were coterminus. He (Fladmark 1978:124) summarized his interpretation of the Paleographic reconstruction of the Northwest coast and refuted more popular "totally glaciated" interpretation by stating:

> The vision of an unbroken wall of ice completely sealing in the Northwest Coast during the Wisconsinan Glaciation should be replaced by the more complex and realistic picture of a Greenland-like shoreline, with major glaciers spilling out to the ocean through trunk valleys, but separated and flanked by strips of ice-free coast, unglaciated headlands and off-shore islands.

Further supporting data for human populations living adjacent to glaciated areas can be found in the abundant ethnographic literature discussing the Greenland Eskimo as well as in de Laguna's (1964:16-18) description of the ethnohistory of the Yakutat Tlingit. She (ibid) describes with vivid clarity the shifting of settlement locales and travel routes in response to a rapidly changing periglacial environment. De Laguna records the relocation of settlements in newly glaciated areas, and even the abandonment and subsequent destruction of one settlement due to glacial advance. Her presentation of both ethnohistoric and historic data leave little room for doubt that man has in the past lived in close proximity to glaciers and glacial ice along the northwest coast.

Fladmark's (1978; 1979) interpretation of the glaciation of the Northwest coast during Wisconsin times may have direct applicability to the study area as suggested by the analysis of the Gull Island exposure in Chinitna Bay (Thorson, Plaskett and Dixon, this report), where Gull Island was exposed to subaerial deposition shortly after deglaciation. These data may indicate that, as Wisconsin age ice retreated and sea level rose, a relatively narrow strip of coast may have provided suitable locales for human occupation. It is also realistic to envision the landward "migration" of terrain suitable for human occupation concurrently with retreating glacial ice, isostatic rebound, and rising sea level.

THE MODEL

The model implemented in the Bering Land Bridge Cultural Resource Study has been used for this study. However, a different ranking system has been employed due to the very different nature of the projected ecological regions analyzed by Stoker (this report). The ethnographic data pertinent to resource procurement discussed in detail in the Bering Land Bridge Cultural Resource Study strongly support the assumption that the subsistence strategy of precontact hunters varied depending on the faunal resources available. A brief synopsis of the Bering Land Bridge model is appropriate before discussing the ranking system employed for the lower Cook Inlet and Prince William Sound area.

Biomass peaks concentrated precontact hunting populations. which through collective efforts were able to maximize the faunal harvest. This form of subsistence strategy resulted in predictable settlement locales which coincided with the occurrence of biomass peaks. Biomass concentrations were restricted to specific locations at specific periods in the seasonal cycle. By this method," precontact northern hunting populations were focused into primary settlements.

One universal in northern hunting cultures is the presence of some form of winter settlement. Such camps may be expected in regions of high productivity which provide seasonal surplus energy harvests necessary to substain a winter settlement, with surplus energy stores being supplemented by species in winter range and/or local small game or marine resources. These factors, coupled with the difficulty of transporting large quantities of fresh meat any great distance from the point of capture resulted in the formation of primary settlements.

Generally, Winter settlements required substantial modification of the natural environment in the construction of some form of winter shelter. It seems probable that such sites will be the easiest to detect using the geophysical instruments presently available for marine archeological survey. Large winter settlements will be located in areas where the greatest possibility exists of securing surplus faunal harvest, For the purposes of this study we consider the following environmental conditions to be the locales most likely to substain winter settlements.

High Probability Areas

1) Non-glacial river mouths and constricted marine approaches to these river mouths, river margins and lake outlets. Estuaries and rivers, particularly those issuing from lakes, would have concentrated anadramous fish and their predators.

2) Natural terrestrial constrictions, such as passes, which funnel large mammal movements.

3) Prominent spits, points, rocky capes, headlands and islands that may have provided habitat for Phocid and Otarid seals and for marine birds. Such habitat is only considered high probability if it occurs in conjunction with one or more additional habitat types, or if there is natural construction which would tend to concentrate these species.

4) Areas of habitat diversity and general high marine intertidal productivity, particularly those which might have prompted extensive machrophyte development. An example of this type of environment would be deep sinuous embayments.

Medium Probability Areas

1) Lake margins. Although the presence of fish and waterfowl resources enhance these areas as settlement locales, they are less likely to be as productive (and consequently less likely to foster winter settlements) as "those listed above.

2) North and south facing slopes. Guthrie (1976) indicated that south facing slopes tend to concentrate grazing mammals during early spring plant maturation and that many times north facing slopes provide wind blown snow free winter range. However, neither of these habitat types concentrate grazers into specific locations where large aggregates of animals can be harvested. Although these areas are generally more productive, the mammals are scattered over a comparatively large area.

Low Probability Areas

1) Any habitat types not listed above.

High, Medium, and Low Probability areas have been transposed "to Bureau of Land Management Outer Continental Shelf Cffice protraction diagrams for the study area. Eight protraction diagrams have been marked with H, M, L, to indicate high, medium and low probability areas (See this report for maps NO 5-1, NO 5-2, NO 5-3, NO 5-4, NO 6-1, NO 6-2, NP 5-8, NP 6-8).

Changes in Lease Block Ranking

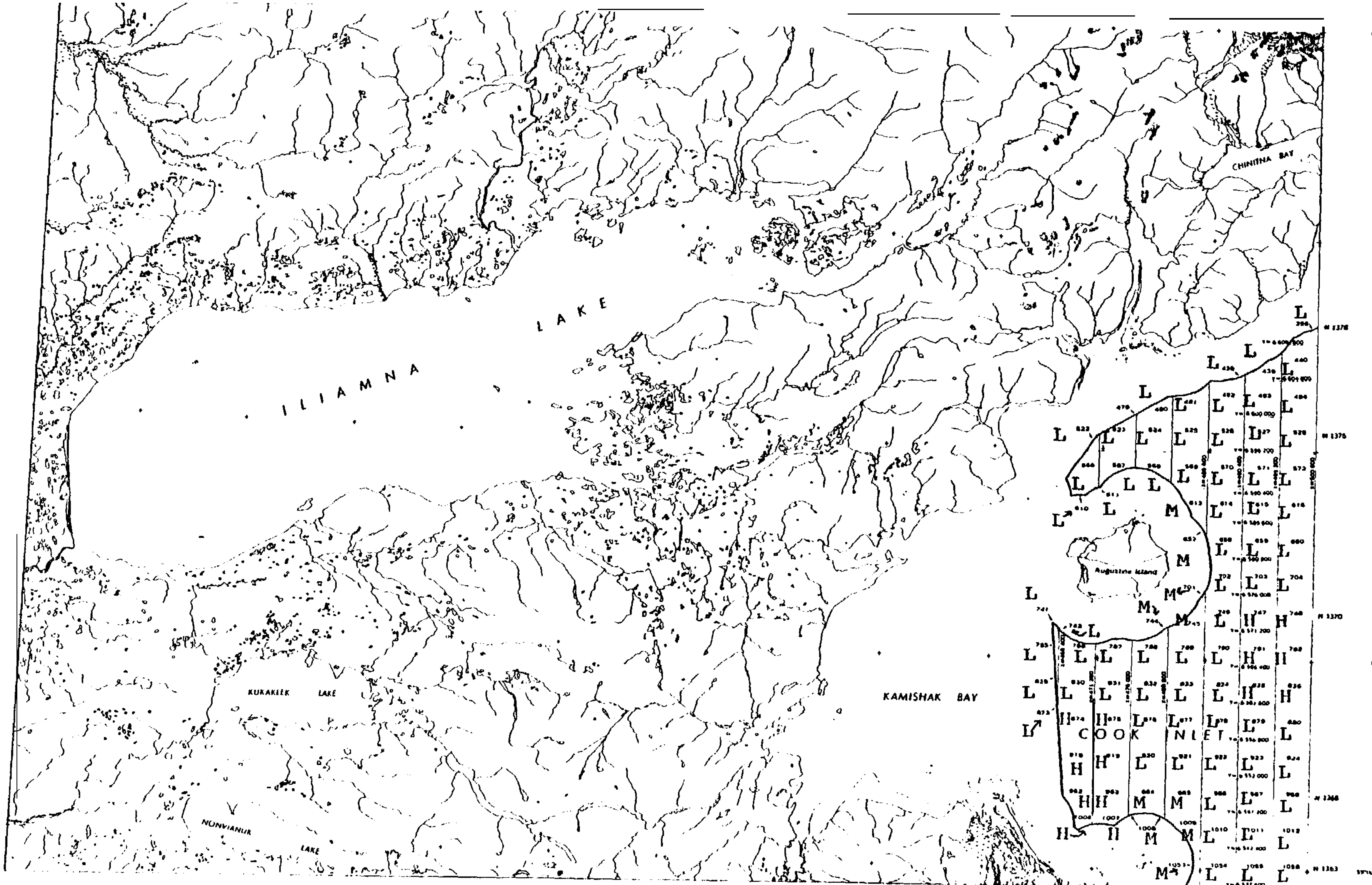
The Lower Cook Inlet Cultural Resource Study overlaps the areas of the Western Gulf of Alaska Cultural Resource Study between 148° and 154° west longitude and 58° and 59° north latitude. The bathymetric data available for the Lower Cook Inlet study are of higher quality than the data which was available during the Western Gulf study. Consequently, more bathymetric detail was discernible in the Lower Cook Inlet study than was possible in the Western Gulf analysis. As a result, it has been possible to refine the ranking for this area. The changes in ranking are listed below and these changes should supercede the ranking for lease blocks as listed in the Western Gulf of Alaska Cultural Resource Study.

Lease Block Number	Western Gulf Study	Lower Cook Inlet Study
Changes on Map NO 5-3, Mt. Katmai		
175	L	H
219-220	L	H
263-264	L	H
306-308	L	H
Changes on Map NO 5-4, Afognak Island		
16-17	M	L
18-20	H	L
28-29	L	H
60-61	M	H
63-64	H	L
65	M	L
72-73	L	H
89-90	L	H
103	L	H
107	H	L
108-109	M	L
116-117	L	H
133-134	L	H
148-150	H	L
153-154	L	H
177-178	L	H
183-188	H	L
192-193	H	L
197-198	L	H
221-222	L	H
226-229	H	L
232-233	H	L
234	M	L
247-248	M	L
265-266	L	H
269-273	H	L
276-277	H	L
291-292	M	L
309-310	H	L
312-313	H	L
320-322	H	L

Maps NO 6-3 and NO 6-4 (no geographic name) covering 58° 00' to 59° 00' N Latitude are not included as they are outside the contract area.

Fig. IV-2. Changes in Lease Block Rankings from Western Gulf of Alaska Cultural Resource Study to Lower Cook Inlet Cultural Resource Study.

PROTRACTION DIAGRAMS



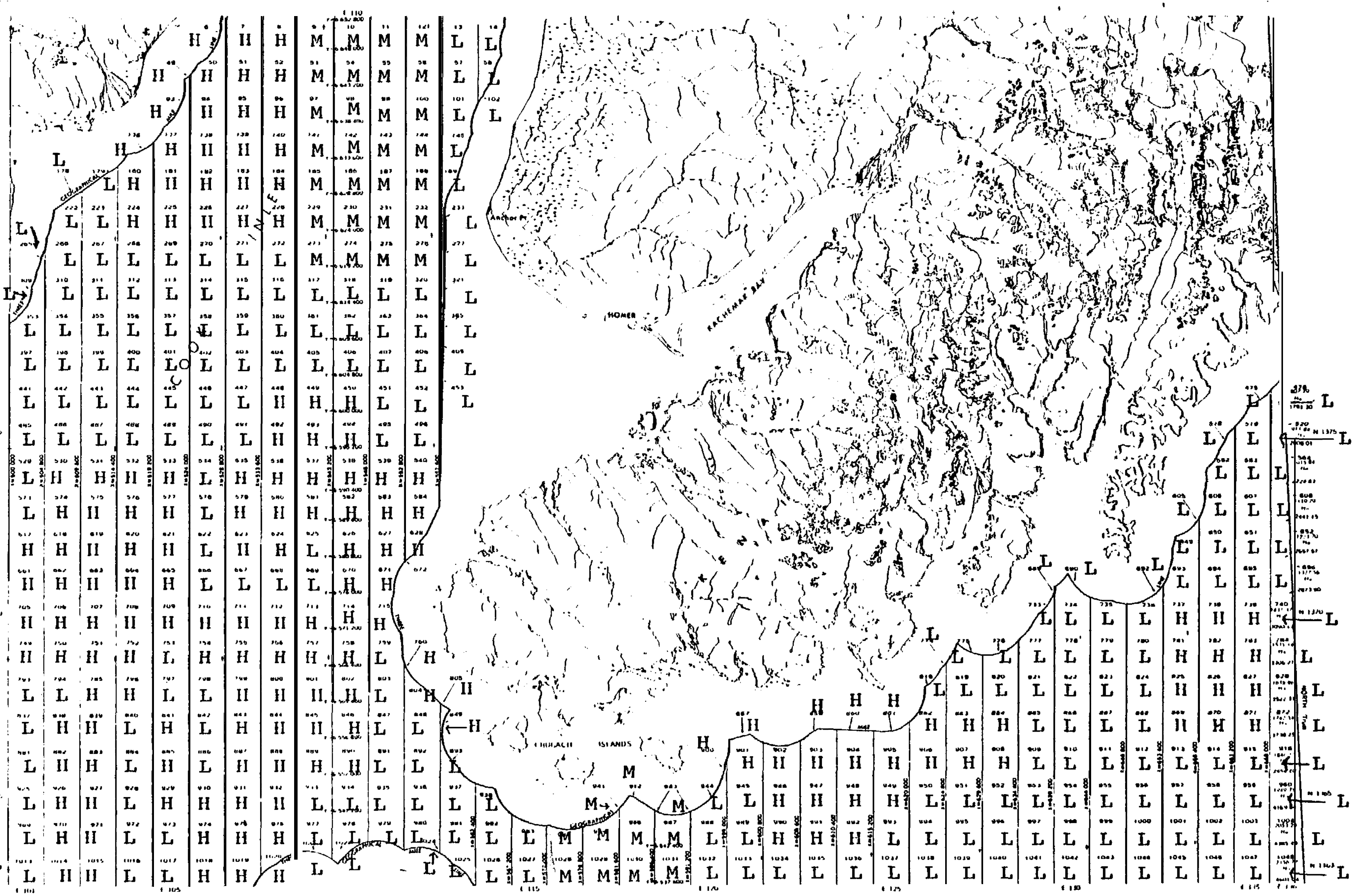
Prepared under contract for the
Alaska Outer Continental Shelf Office
Bureau of Land Management
U.S. Department of the Interior
under contract No. AA551-CT8-29

L Area of low probability

M Area of medium probability

H Area of high probability

LOWER COOK INLET CULTURAL RESOURCE STUDY



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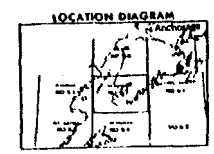
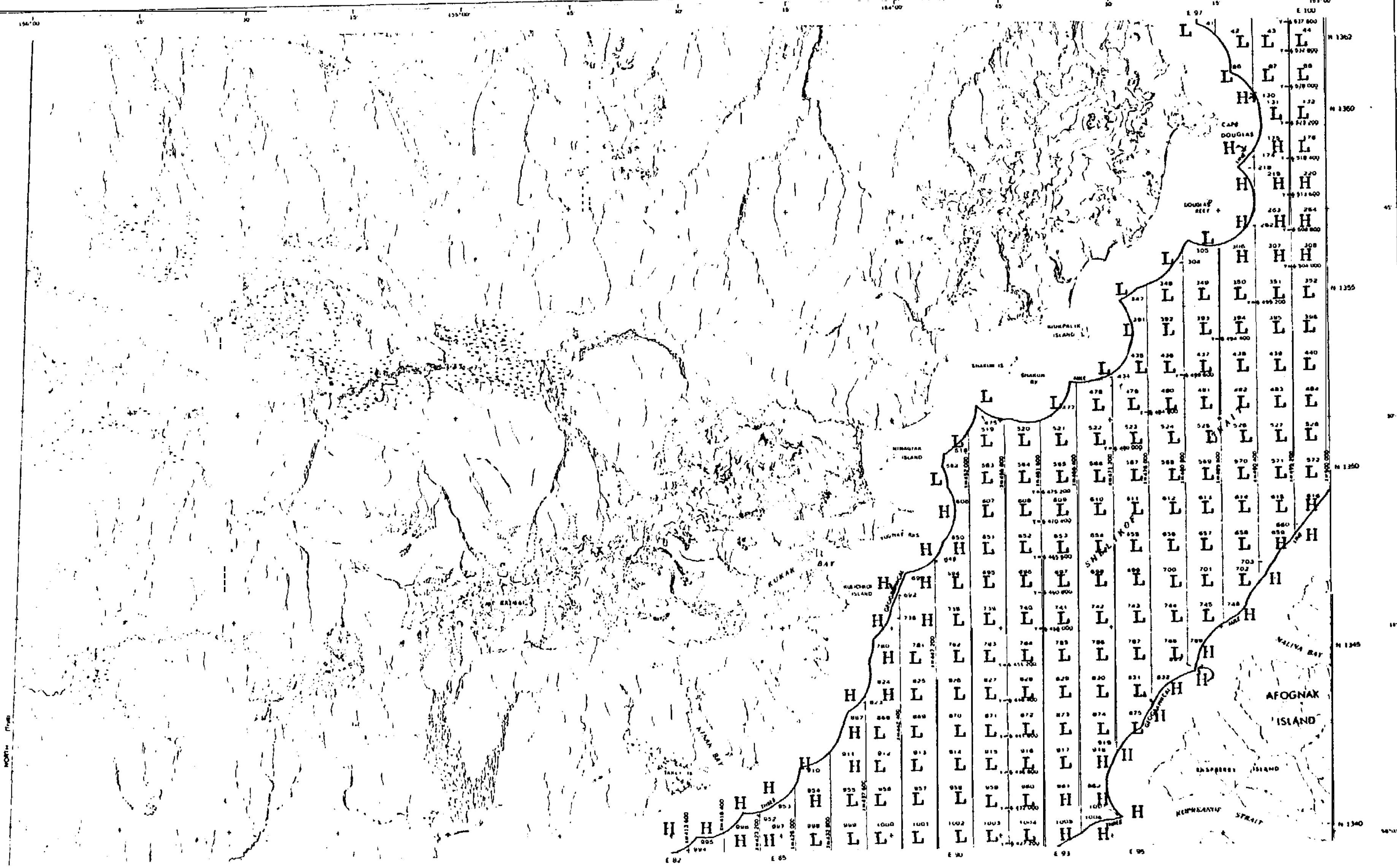


NO 5-2

SELDOV



LOWER COOK INLET CULTURAL RESOURCE STUDY

L Area of low probability

M Area of medium probability

H Area of high probability

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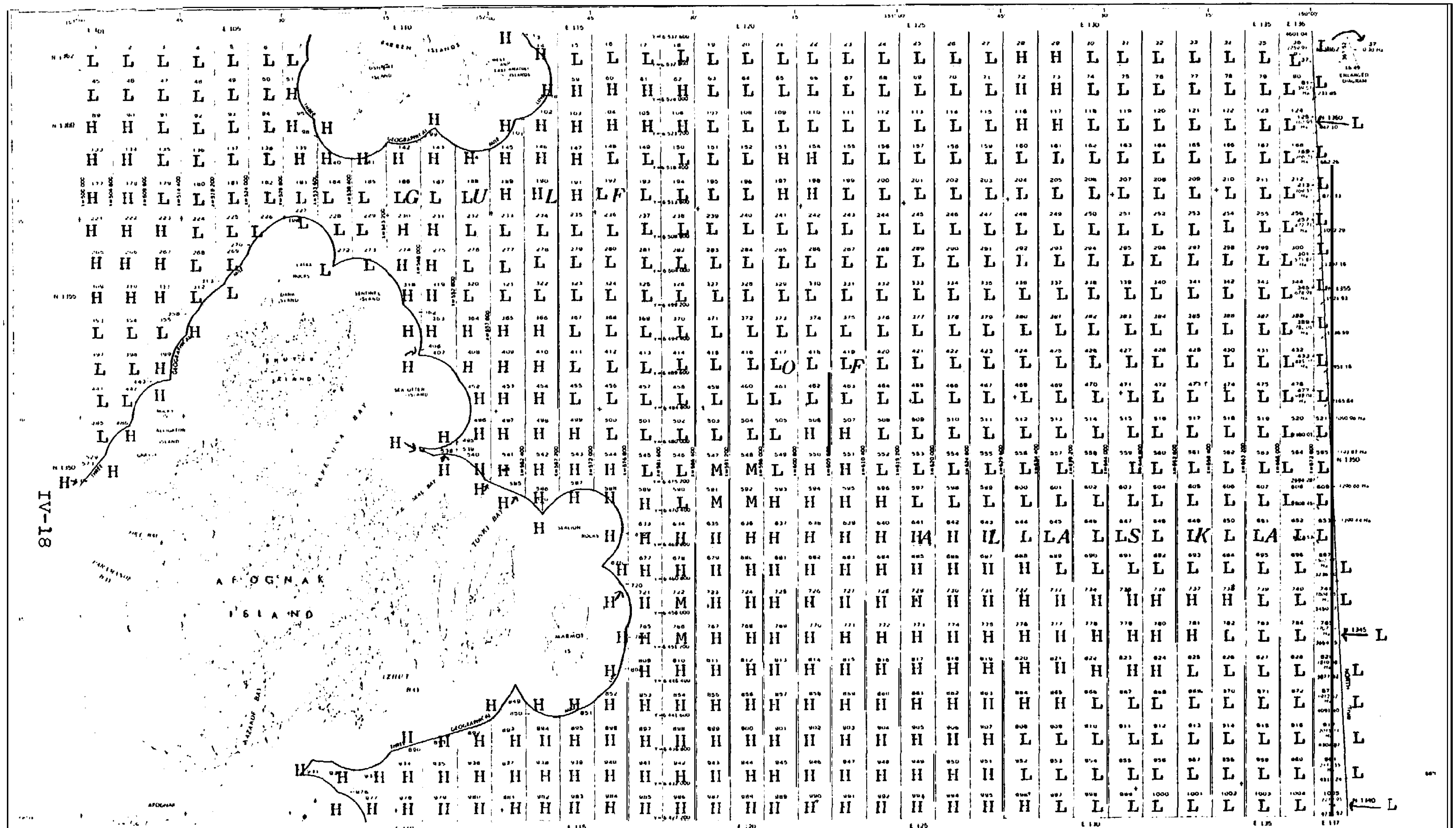

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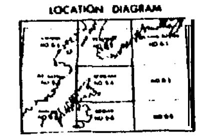
L	Area of low probability
M	Area of medium probability
H	Area of high probability

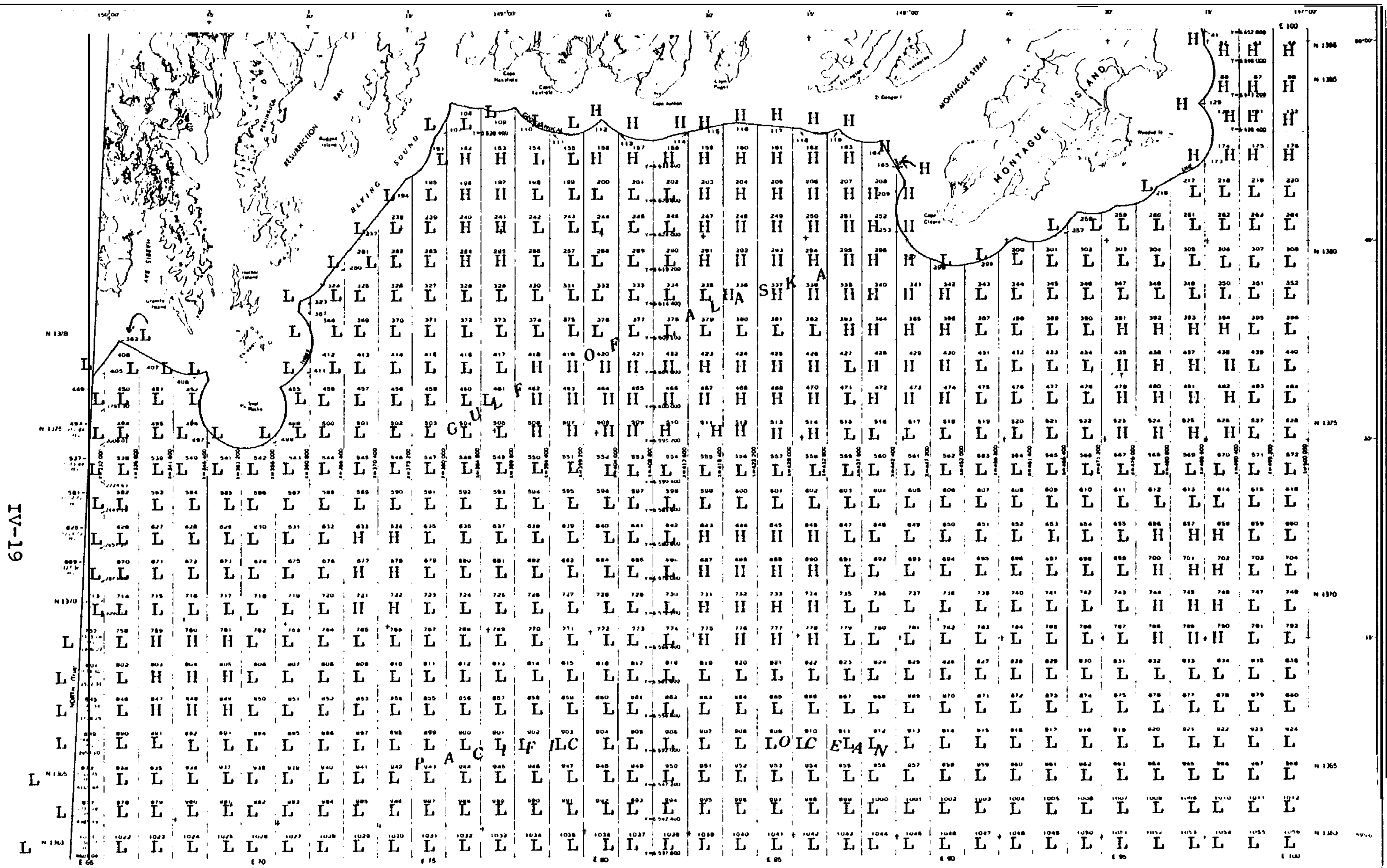
LOWER COOK INLET CULTURAL RESOURCE STUDY

LOCATION DIAGRAM



NO 5-4

AFOGNAK



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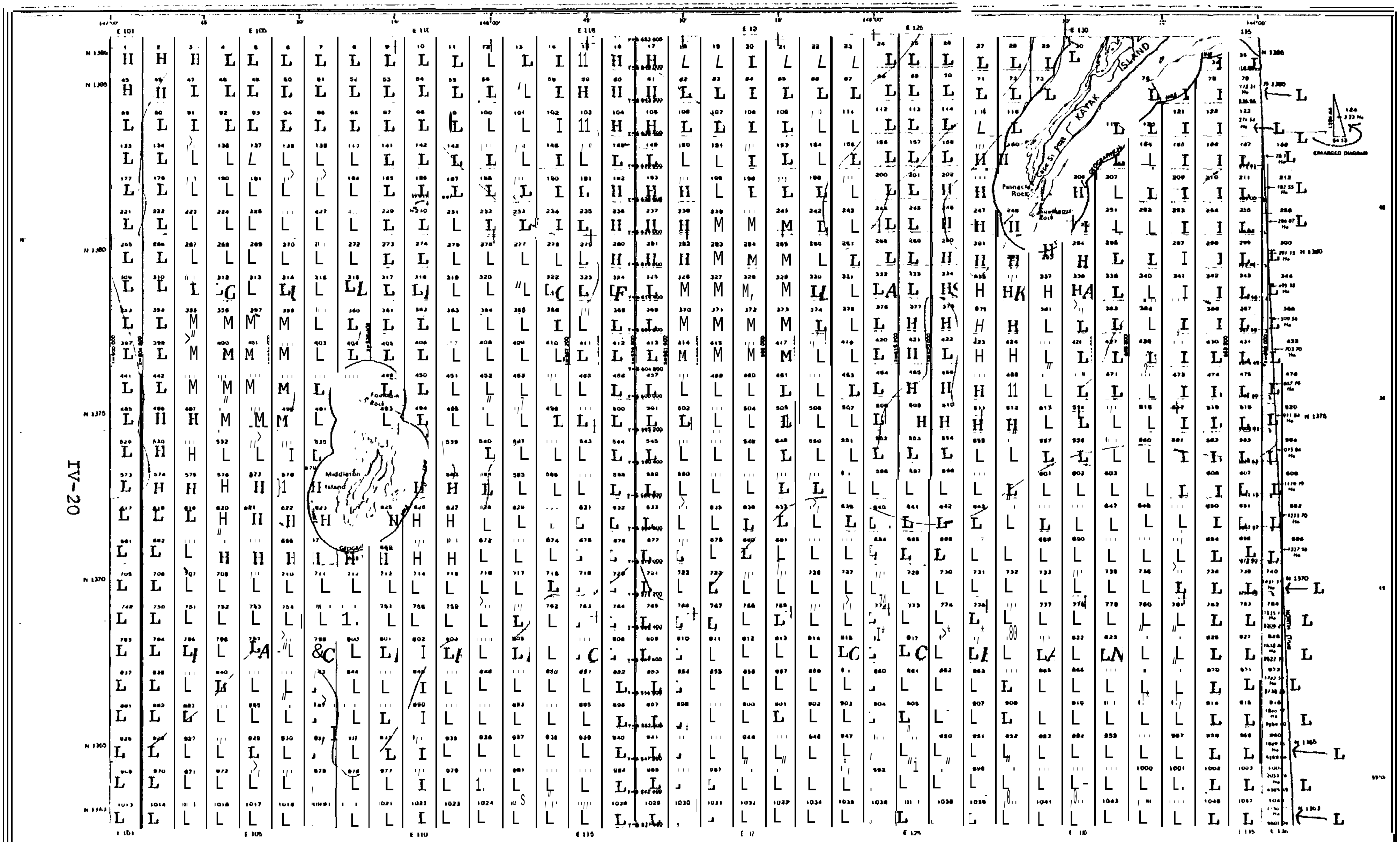
U S Department of the Interior
under contract No AA551-CT8-29

L	Area of low probability
M	Area of medium probability
H	Area of high probability

LOWER COOK INLET CULTURAL RESOURCE STUDY

BLYING SOUND

NO 6-1



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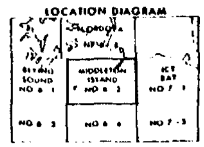
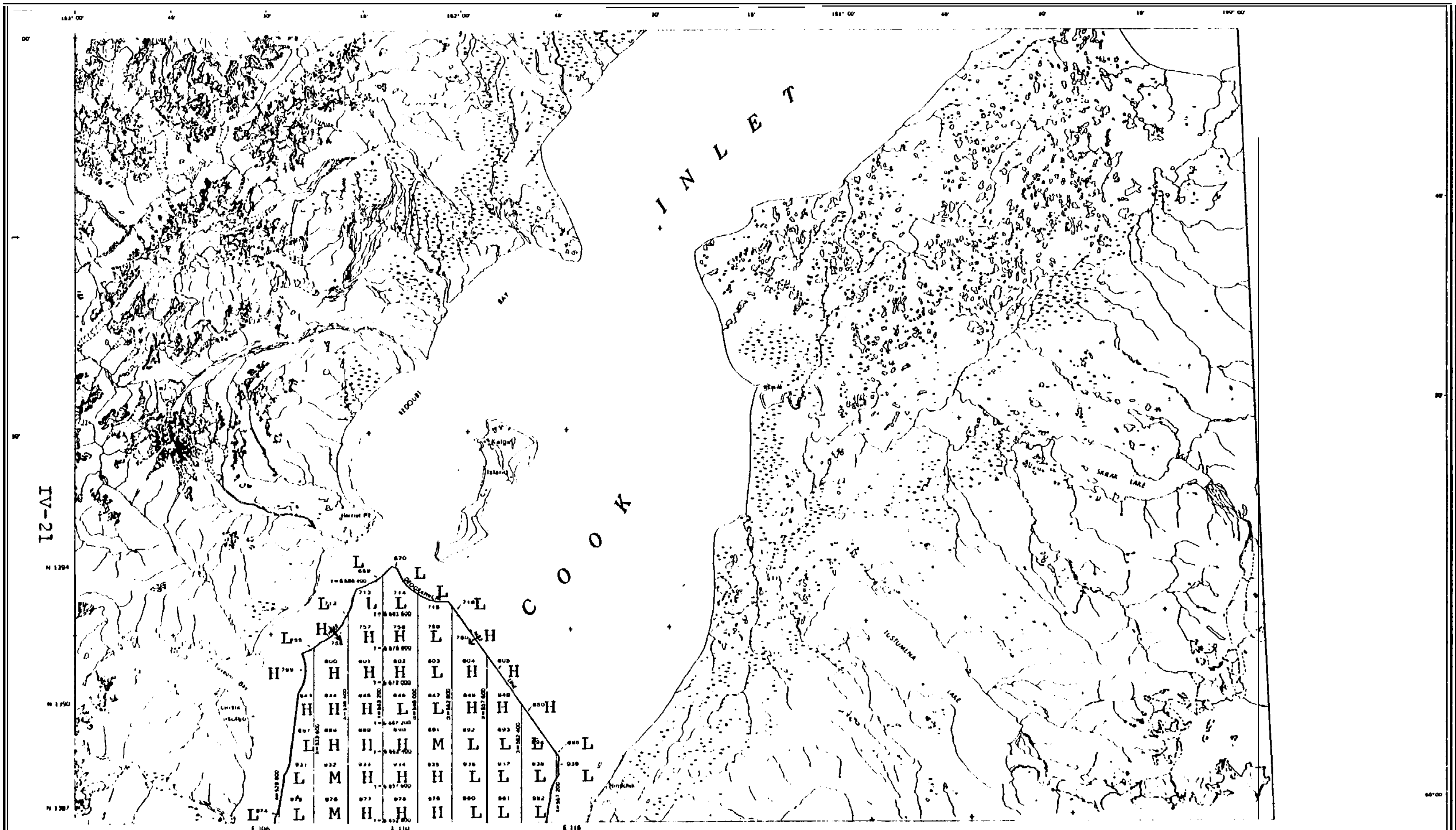


NO 6- 2

MIDDLETON ISLAND



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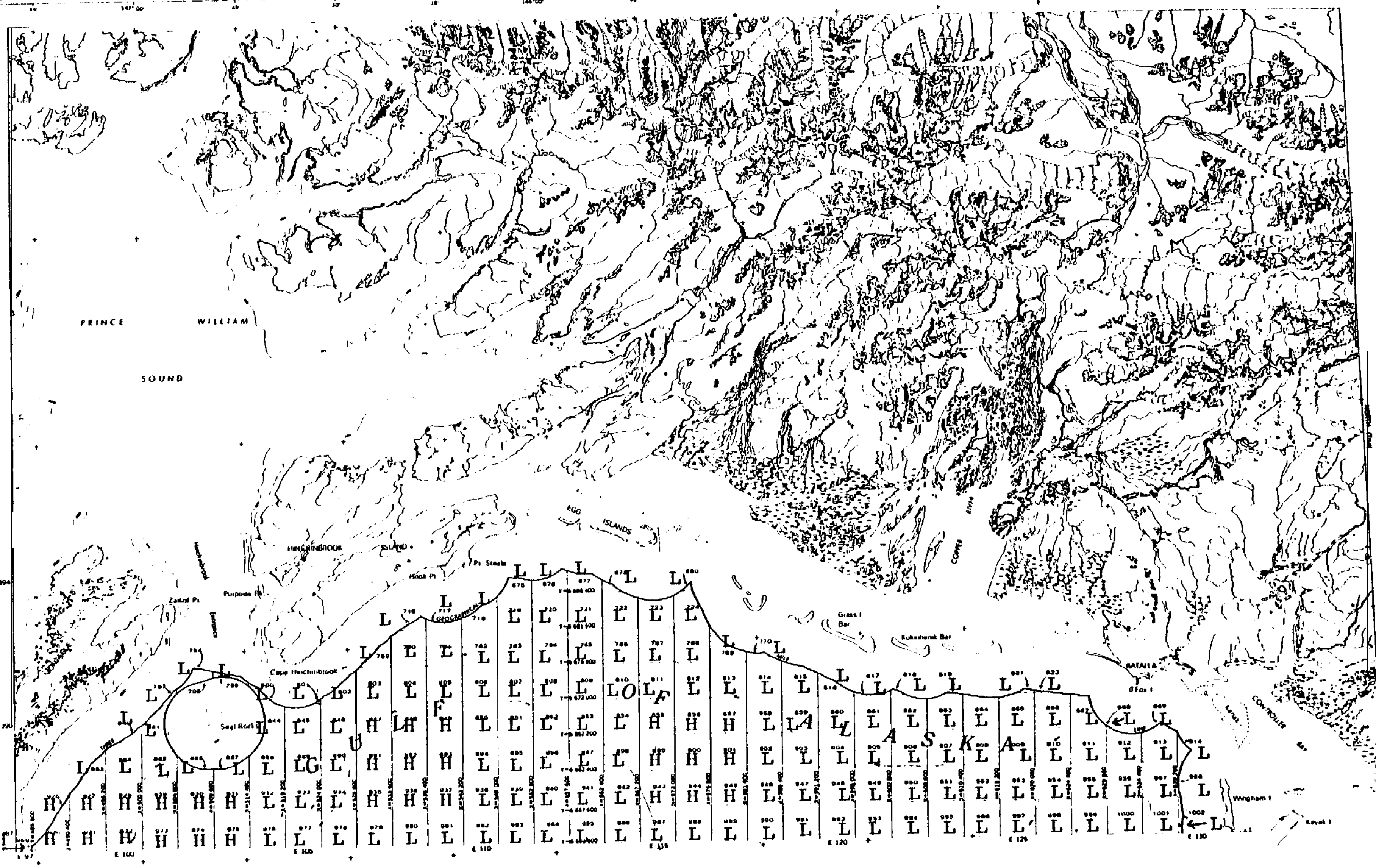
L — Area of low probability
M — Area of medium probability
H — Area of high probability

LOWER COOK INLET CULTURAL RESOURCE STUDY



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L Area of low probability

M Area of medium probability

H Area of high probability

LOWER COOK INLET CULTURAL RESOURCE STUDY

LOCATION DIAGRAM

CORDOVA

6–8

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